AGRICULTURAL ENGINEERING

Published by the AMERICAN SOCIETY OF AGRICULTURAL ENGINEERS

Headquarters of the Society: Saint Joseph, Michigan

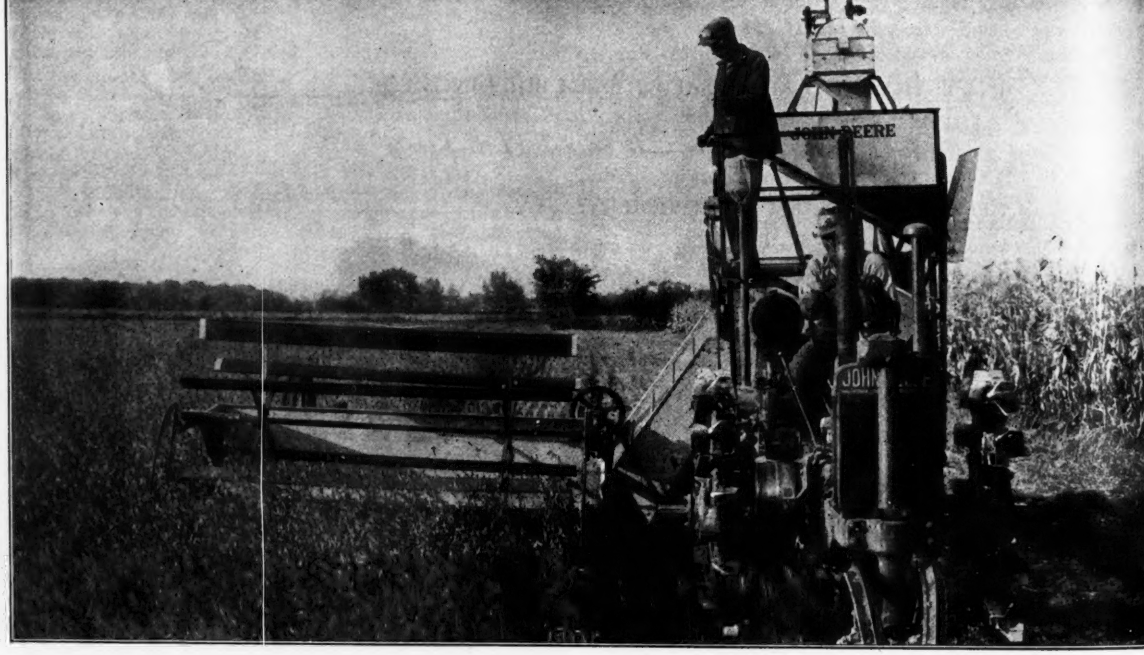
RALPH U. BLASINGAME, *President* RAYMOND OLNEY, *Secretary-Treasurer*

VOLUME 17 OCTOBER 1936 NUMBER 10

CONTENTS

Published monthly by the American Society of Agricultural Engineers. Publication office at Benton Harbor, Michigan. Editorial and advertising departments at the headquarters of the Society, St. Joseph, Michigan . . . . Price $3.00 a year, 30 cents a copy; to members $2.00 a year, 20 cents a copy. Postage to countries to which second-class rates do not apply, $1.00 additional . . . . The Society is not responsible for statements and opinions contained in papers published in this journal; they represent the views of the individuals to whom they are credited and are not binding on the Society as a whole . . . . Entered as second-class matter, October 28, 1933, at the post office at Benton Harbor, Michigan, under the Act of August 24, 1912. Additional entry at St. Joseph, Michigan. Acceptance for mailing at the special rate of postage provided for in Section 1103, Act of October 3, 1917, authorized August 11, 1921 . . . .
The title AGRICULTURAL ENGINEERING is registered in U. S. Patent Office. Copyright, 1936, by American Society of Agricultural Engineers.

When extra *Load Capacity* counts.... count on HYATT!



JOHN DEERE Model A General Purpose Tractor pulling JOHN DEERE No. 7 Combine, harvesting soy beans. Hyatt Roller Bearings serve in this and other JOHN DEERE equipment, including mowers, ensilage harvester, corn picker, corn binder, etc.

Unseen, unheeded, these high-capacity bearings handle their appointed tasks silently, smoothly, efficiently. Years of hard service in all types of equipment, under all kinds of conditions, do not lessen their original accuracy, strength, or performance. Hyatt Roller Bearing Co., Newark, Detroit, Chicago, Pittsburgh, San Francisco.

AGRICULTURAL ENGINEERING

VOL 17, NO 10 — EDITORIALS — OCTOBER 1936

Liaison Function of Agricultural Engineers

A STEP forward in industrial recognition of agricultural engineers and agricultural engineering is seen in the Republic Steel Corporation's announcement of an agricultural extension bureau headed by a young agricultural engineer.

What makes it particularly significant is the viewpoint expressed by the company in its announcement of the function and policy of the bureau. As stated by R. M. Girdler, president, they have in view ". . . . . . contributing generously toward the solution of those problems which have to do with the proper and most economical use of steel products on the farm. . . . . The farmer's consumption of steel has been accepted as a matter of course and the industry has done little or nothing in the way of organized, practical research to enable rural customers to use its products most efficiently and economically. . . . . . In urban markets it has long been the policy of steel manufacturers to make available to customers the combined intelligence of large and highly-trained metallurgical and engineering staffs in order to develop new and 'tailor-made' steels and to promote their proper specification, fabrication, and use. . . . . . Republic . . . (has) determined to offer the same type of technical service to . . . . . agriculture."

This pictures effectively a type of liaison service which many agricultural engineers are especially qualified to render. Their agricultural background, training, and contacts enable them to see—yes, to foresee to a certain extent—and to understand farm problems, requirements, and opportunities. Their engineering training and experience enable them to express these in engineering language to engineers in charge of industrial research and production. Likewise they are qualified to understand and to talk to farmers in farm language of profitable farm use methods and opportunities, care requirements, and limitations of engineered materials and equipment produced by industry for farm use. They are qualified to conduct engineering and economic research in the farm application of industrial products.

They are qualified to represent and to present the viewpoint of farmers in the councils of industry, and of engineering in the councils of agriculture.

Not all agricultural engineers are equally qualified nor would they find their greatest field of usefulness in this important liaison work. But the man who is qualified for it is, in fact, an agricultural engineer, regardless of the name given his initial training. And the colleges and universities with professional courses in agricultural engineering are every year turning out graduates with excellent basic training to meet this particular need.

We expect to see a growing spirit and effectiveness of cooperation between agriculture and industry as still more industries see fit to support a definite, qualified agricultural engineering liaison between their research and production engineers and the farm users of their products or services. To the Republic Steel Corporation, our congratulations on a progressive step in this direction.

Shall Engineers Invade the Economic and Social Sciences?

CURRENT consideration of the extent to which engineers can, or should attempt, to extend their field of service by invading the economic and social sciences, seems to provide three schools of thought.

There is the extreme view that engineers should take over or absorb these sciences, put them on a sound quantitative foundation, and apply them in an engineering manner as a constructive service to humanity, through industry and government.

There is, on the other extreme, the view that engineers should tend strictly to their technical knitting, concentrating on providing the best possible bridges, drains, machines, and other engineering works on the order, insight, and moral responsibility of industrialists and statesmen of proven ability to pay and to "get ahead" in this world.

And there is the intermediate viewpoint that engineers should know just enough about the economic and social sciences to enable them to understand and to interpret to the nonengineering world the economic and social significance of their technical progress.

We have no first-hand information as to substantial advocates of extensive engineering invasion of economics and sociology, or of their line of reasoning. Apparently it is based on the recognized ability and concrete achievements of engineers in their technical field; the relatively academic status of economics and sociology; and the apparent need of something being done to improve the economic and social opportunities of a large majority of all people.

A leaning toward the other extreme, with particular reference to agricultural engineers, is shown in H. B. Walker's paper, "Looking Ahead in Agricultural Engineering," in AGRICULTURAL ENGINEERING for July. To reemphasize important leadership in this direction we quote him in brief:

"Speaking as an engineer to engineers, I am convinced, and I feel you must agree with me, that our future as engineers in the service of agriculture, depends upon our strict adherence to tangible values in solving our problems and the measure of our services must depend upon the direct benefits accruing.

"This need not imply that we as individual citizens should be indifferent to such problems as the social and human benefits accruing from our endeavors, but if we achieve in the development of the material things with which engineers must work, we cannot deviate very far from the use of tangible values to obtain direct results.

* * * * *

"Statesmen may pass laws calling for physical developments, the benefits from which are to be measured in some degree by social values. Included in these programs may be engineering works of importance. As I see it, the engineer need not hesitate to take his place in the engineering phases of such projects so long as he is not restricted or restrained in the honest practice of his profession, even though he personally may be in doubt as to the ultimate social objectives. The latter are the responsibility of society as a whole, and somewhere in society there should be those who are as well or better equipped than the engineer to analyze and place such intan-

gible values. The engineer, however, must accept full responsibility for the technical integrity of his part of the project. That is, his machines should be capable of rendering a service; the dams and bridges he builds should stand up; his warehouses should meet specific requirements; but social and certain intangible types of economic outcomes should nòt be placed at his doorstep. As I see it, for the engineer to assume such a responsibility is to invite loss of technical prestige.

* * * * * *

"A comment appearing in 'Engineering' is significant and worth repeating here: 'The complexity and extent of the engineering profession make it impossible for any individual to have a detailed knowledge of more than a relatively small part of the total field.'

* * * * * *

"The agricultural engineer works in an applied science field. To him the application must be of a practical working type. Mere theory will not bring satisfaction, or esteem, to the engineer working in this field. *He must be practical.*

* * * * * *

"To me our professional future appears brightest if we hold ourselves rather rigidly to the technical and, of course, tangible phases of engineering as related to agriculture. While we should be concerned with social progress the same as any good citizen should be, we invite disaster to good professional service when we try to design social justice into production machinery."

These factors, the essentially tangible nature of engineering training, technique, and works; the exhaustive complexity and breadth of the strictly technical field of engineering; and the wealth of opportunity therein, are strong centripetal forces tending to hold engineers close to the central physical science of their profession.

An example of the intermediate view as presented in C. E. Hirshfield's paper on "The Engineer Today and Tomorrow," appearing in "Mechanical Engineering" for August, provides some thoughts worthy of consideration.

Mr. Hirshfield disapproves of engineers leaving their brain children as foundlings on the world's doorstep. Of this he says,

". . . . I say to you in all sincerity that I think the engineer has ignored a very important responsibility and still continues to do so. In a very short period of time the engineer has turned our civilization upside down, but he has not thought it incumbent upon him to offer to solve or assist in solving any of the problems which his works have introduced. Those of you who are fathers realize a certain responsibility to your offspring upon which it is not necessary for me to enlarge. But when it comes to your mental offspring, the children of your brain, you toss them into the world and assume no further responsibility for them. If your son gets into a jam you try to help him out. If the offspring of your brain gets into a jam you say, 'That is for somebody else to straighten out; the technical development is as far as I go.'

"I do not believe you can longer maintain this attitude.

* * * * * *

". . . . To my mind, the interpretation of our works in their social and economic connotations is now a lot more important than the making of further materialistic or technological developments. I say this to you as an engineer; as one who has the same mental makeup, the same urges, and the same limitations as have you to whom I say it."

As to means of interpretation, Mr. Hirshfield would have engineers learn the common language of those to whom they would interpret.

"The time has come when engineers must learn to talk the language of their fellow beings, other than engineers, so that we can talk to them in words that they can understand. The time has come when we must make it our business to find ways and means of explaining to the masses the real significance of our works. The time has come when we must begin to educate ourselves to the ability to think about the nontechnical problems faced by humanity."

As a warning against trying to extend engineering services too far, Mr. Hirshfield says,

". . . . I am certain that we should not start out to solve all the problems of the universe. We shall still be engineers, and very few engineers are going to be successful politicians, lawyers, or spellbinders . . . ."

As to public acceptance of the engineers' economic and social interpretations, Mr. Hirshfield believes,

". . . . We can gradually learn how to interpret our works in terms of economic and social significance, and I think we shall soon discover that, if we will only give our fellow citizens the rights and wrongs of such questions, they will accept them from us because they recognize us as individuals who tell the truth.

"Have you ever heard any responsible person question the probable performance of a work of engineering? When the engineer undertakes the putting of a bridge across a river, the public does not doubt a successful outcome . . . ."

Certainly if engineers can learn to interpret economic and social forces and reactions with the same order of accuracy they achieve with physical forces and reactions, their words on the economic and social significance of their works will command respect.

And Mr. Hirshfield offers engineers a method of gaining insight into the significance of their works. It is the method of studying economic and social history from as far back as it is recorded. He says he has tried it and found it wonderfully helpful.

". . . . It gives an insight into the expectable reactions of human beings which cannot be obtained in any other way that I know. It gives a knowledge of many attempted applications of social inventions which is exceedingly useful in attempting to evaluate what are supposed to be new suggestions. He who knows the history of human experience speaks with much greater authority than does he who merely wishes or guesses.

"This method is not foolproof. Conditions today may be different from those existing during an earlier experiment. . . . . What were the given conditions? Out of the great multitude existing at any one time, which were controlling and which merely contemporaneous? Your conclusions will be correct only as you succeed in eliminating unnecessary factors from consideration.

"If you will do your work carefully, you will find that in a gross sort of way you can interpret history in the terms of social and economic movements and that that interpretation will act to put your thinking on a more factual basis than has in general existed in those fields."

We would not presume to guess the extent to which Mr. Hirshfield's extra study of social and economic history can profitably be injected into the already complex and rich technical engineering field pictured by Mr. Walker. Perhaps, if they could talk over each others viewpoints on the question, they would not seem so far apart.

We suggest for consideration in connection with this problem the matter of individual differences. Undoubtedly some engineers always will find their greatest usefulness in strictly technical work without regard to its ultimate significance. Other engineers, of whom there are numerous examples, show capacity to fill executive positions in which they are confronted with deep, far-reaching economic and social problems. Just as some engineers are better adapted to one technical branch of their profession than another, some may be better adapted than others to master the social and economic significance of engineering works.

Perhaps a comparatively small number of engineers with special adaptability for the purpose could interpret the economic and social significance of engineering developments to the rest of the engineering profession, as well as to the rest of the world.

Perhaps a few case studies of engineering developments that have served economic and social purposes; of engineering effort wasted for lack of economic and social foresight; of engineers who have succeeded and others who have failed, both within and beyond the technical boundaries of their profession, would help to clarify the extent and manner in which engineers may increase their service to humanity by improving their understanding of the social and economic effects of their works—past, present, and contemplated.

Farm Building Costs and Appraisals

By G. B. Hanson

DURING the past few years two important factors affecting farm building valuations have caused a considerable amount of confusion in appraisal and valuation of farm buildings. These factors have been (1) a wide fluctuation in the cost of materials used in farm construction, and (2) the unparalleled changes in the status of farm real estate in the United States as a whole. In addition to these two more recent factors, there has apparently always been a great lack of precision and uniformity of system in the matter of arriving at farm building values. If the distressing experiences in farm real estate over the past few years can help point a lesson, the present seems an opportune time to carefully scrutinize farm building costs and appraisal practices. Agricultural engineers are vitally concerned with any improvements which can be brought about in this important field.

The importance and size of the problem of farm building valuation is probably not generally recognized; neither is there adequate appreciation of the relation of this problem to such groups as farm managers, tax assessors, farm loan agencies, companies writing farm building insurance, institutional landlords holding farm real estate, and others.

Some idea of the size of the problem is gained when it is recalled that farm buildings on the more than 6,000,000 farms in the United States carried a reported value of about $13,000,000,000.00 in the 1930 census. It would seem that an investment of $13,000,000,000.00 in American farm buildings may be considered a very respectable item, and one well worthy of more serious attention. This tremendous investment warrants a more careful scrutiny by agricultural engineers, manufacturers of building materials, farm appraisers, and many other groups, and each group will profit much by more careful study of those phases of the problem which affect it most.

A study of farm building costs and valuation is not only important when this tremendous investment is considered in its entirety, but it becomes even more important to the farmer and certain other groups when it is considered on the individual farm. The farm owner commonly has from 20 to 50 per cent or more of his farm investment tied up in farm buildings. And the interest on this part of his investment, plus the upkeep and depreciation on the buildings, becomes one of the farmer's major fixed costs operating to reduce net income of the farm. For this one reason alone it is plain that anything which can be done to reduce annual farm building costs will greatly benefit the agricultural industry, and a careful consideration of farm building costs and values would seem to be a logical starting point. It should be pointed out here that reducing farm building costs should in no wise be assumed to result in reducing the amount of business for materials going into farm building construction. Just as less expensive automobiles resulted in a greater volume of business, and for much the same reason, it seems likely that reduced building costs would permit of a much greater volume of farm building.

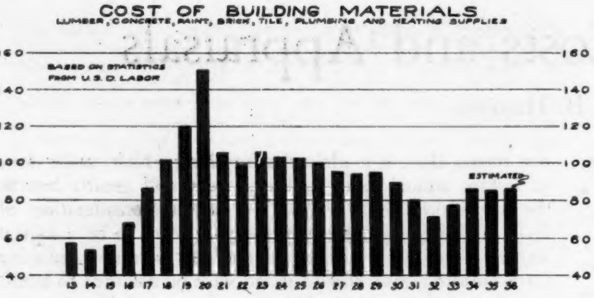
A knowledge and analysis of present day farm building costs and valuation procedure is also important and useful in other ways. Today's unit costs of common farm building construction will serve as a measure of the price which may be secured for new products or construction materials now being developed. It should be recognized that materials and equipment sold in the farm building field must measure up high in service and utility value, and be moderate in cost, in order to compete with materials now commonly used. In general the high-priced, high-class materials, specified partly for the show and prestige connected with their use, find and deserve little demand in the farm building field. It should not be construed from this that farm building materials, or the finished product, must be cheap. Cheap products are oftentimes more costly, for the service rendered, than more expensive materials, and there is no doubt but what this commonly known truth is disregarded far too frequently in farm building construction. Native materials and other low-cost products are often so used as to make satisfactory service impossible. In this connection it may be that the college agricultural engineering departments, the extension services and the county agricultural agents can add to their past good record by offering repeated demonstrations of the proper use of many common building materials.

Before leaving the matter of importance of farm building costs and valuation, it should be noted that there is a decided dearth of good information about the true value of a farm building. Any farm building, with the possible exception of the dwelling, has value only as it contributes to the earning power of the farm. Much remains to be done in the way of measuring the income which can be attributed to the various farm buildings under different farming types and management practices. Perhaps too much detail and refinement in such a study is not warranted,

---

Presented before the Farm Structures Division at the annual meeting of the American Society of Agricultural Engineers, at Estes Park, Colo., June 1936.

Author: Project engineer, Resettlement Administration.



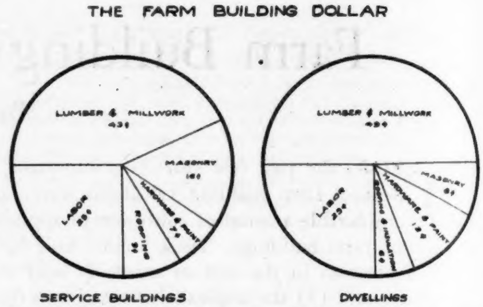


FIG. 1 (LEFT) VARIATION IN THE COST OF BUILDING MATERIALS. FIG. 2 (RIGHT) DIVISION OF COSTS FOR NEW CONSTRUCTION OF FARM SERVICE BUILDINGS AND DWELLINGS

but it seems logical that some surprising results may be obtained from the study. Some crops and farm practices have a much higher building requirement than others, and it may well be that some will, over a period of years, give a far higher return per dollar of building investment than others. This paper will shed no direct light on the subject, but it is felt that here is a matter which needs considerable study by agricultural engineers and farm managers.

Because the commonly accepted basis for judging the value of a farm building is replacement cost new, it becomes important to examine with some care the data available on present material and labor costs. Referring to Fig. 1, it is noted that the cost of building materials has fluctuated considerably during the past twenty years. From an index average of around 55 in 1914 there was a rapid rise in building costs through the war period, reaching a peak of about 150 in 1920. The general business recession of the following year, however, tumbled costs down to about 105, and from that year on through 1929 there was a levelling off and moderate decrease in building costs. Beginning in 1929 building costs began another rapid decrease from about 95 that year to about 70 in 1932. However, 1933 was a year of rapidly increasing cost, and with moderate increases this year, average building costs are now only about 15 per cent below the 1926 average and less than 10 per cent below the 1929 average.

Since this graph shows only yearly averages, it does not reflect either the extreme high or low of materials costs for the given period. Likewise, since the graph shows the average cost of several of the most important building materials—lumber, cement, paint, steel, brick, tile, and plumbing and heating supplies—with the 1926 average figured as 100, it does not give a complete picture of the trend of materials costs for farm buildings. Examination of Fig. 2 discloses that in average farm building construction, the cost of lumber accounts for almost twice as much of the farm building dollar as all other kinds of materials put together. This means that fluctuations in the cost of lumber will ordinarily be far more important than changes in cost for the other materials. Considering the past five-year period, it is noted that the cost of lumber has increased from about 55 in 1932 to almost 90 in the early part of 1934, based on 100 for the year 1926. This is an increase of about 60 per cent, compared with an average increase in cost of about 25 per cent for all building materials. Average costs decreased a little during 1935 compared with 1934, but present indications are that average materials costs for 1936 will show a moderate increase back up to about the 1934 level. Given further improvement in the general economic situation and with building construction in all lines now beginning to come back strongly, it would seem reasonable to expect moderate increases in building costs in the immediate future.

Fortunately, labor costs involved in farm building construction have not been unreasonably high in most rural areas. The very nature of the agricultural community, taken with the fact that the average farmer is of necessity something of a mechanic, makes it seem unlikely that unreasonably high labor charges in farm buildings will ever obtain. Since most common farm building construction is relatively simple work, much of the labor cost is ordinarily taken care of by contributions of the farmer's own labor, and a tremendous amount of annual farm construction is completed without the assistance of outside skilled labor.

Fig. 2 shows that labor in average farm building construction amounts to about 25 per cent of the total cost of the building, whether it be service building or dwelling. There will, of course, be some variation from this figure in different regions and with different kinds of buildings, but a study of new building construction costs on several hundred midwestern farms, in 1934 and 1935, proved that with regular farm carpenter crews and typical construction, the variation is surprisingly small for jobs of any size. In fact, many farm building contractors bid on jobs figuring their total labor charge as one-third of the total materials cost, which is of course the same as 25 per cent of the total cost. In agricultural areas neighboring large cities it is found that the labor cost often amounts to as much as 30 per cent of the total construction cost, and, conversely, in areas far from large centers of population it may drop as low as 20 per cent of the total cost.

The figures above refer to new construction only, and therefore represent only a part of the expenditure for farm buildings. Repair and remodeling expenditures are fully as important or more important to many concerned with the farm building problem. Because of the great variety of repair problems, the relation of labor and materials costs to the total repair cost is quite different than in the case of new construction.

In the first place, the labor cost shows a greater amount of variation from the average and may commonly run anywhere from 30 to 100 per cent of the materials cost. The labor cost for repair jobs also averages higher than for new construction. Tabulation of labor and materials costs for several hundred sizable repair jobs has shown that, on the average, the labor cost will be about 50 per cent of the materials cost, compared with 33 per cent for new construction. This higher labor cost appears to be due to two things. Perhaps most important is the fact that a repair job ordinarily entails a good deal of work in tearing out the useless materials before productive labor in installing the new materials begins. Oftentimes, too, as in the case of foundation repairs, the labor involved may be as much as

for all new construction and yet there is a comparatively small cost for new materials. Another factor that has an important bearing both on the higher cost for labor and the greater variation in cost for repair jobs is that it is much more difficult for the contractor to estimate his labor costs on repair jobs than it is on new construction. This results in a wider spread of bids on labor contracts for repair jobs than for new buildings.

Up to this point it has been convenient to employ the word "value" in its ordinary and somewhat vague sense. It becomes necessary, however, to define what is meant by "value" with regard to farm buildings, and to examine certain factors which create value. If building value is judged entirely on a basis of the replacement cost, it becomes apparent that the value obtained is a physical value, which may or may not reflect the real value to the farm. No building is considered to be worth more than that building itself adds to the value of the land it occupies. For this reason the physical value oftentimes falls far short of a good measure of farm building value, and it is necessary to carry valuation procedure one step further. The physical value of a farm building makes a poor measure of its real value because it does not measure value from the standpoint of usefulness in the farm set-up. In order to arrive at sound agricultural values for farm buildings, then, the consideration of usefulness or "utility" is of utmost importance and because of this the physical value must often be modified by the appraiser to secure the real agricultural value or "utility" value. As an example of this kind of an adjustment which the appraiser must often make, consider the case of a ten-room house on a moderate-sized dairy farm which may have a replacement cost new of, say, \$3,600.00. Obviously the average farm operator could well get along with a seven or eight-room house which could be built for \$2,700.00. Here is a difference of \$900.00, plus the additional upkeep expense, for something not needed. The appraiser in such cases must then make a sizable adjustment of the physical value if he is to arrive at a real agricultural or utility value for this house. The "utility value" as here defined is the ultimate value of greatest interest to most farm building appraisers. Physical value is then more or less incidental, but makes a convenient and practical stepping stone in arriving at the utility value.

Having now defined the particular kind of value of greatest interest to farm building appraisers, it is important to see what factors make up this value. In general, the farm building designed and well-constructed to meet the requirements of farm management practice on the particular farm in question has a high utility value. The building must be of proper size to meet the needs of the farming unit, and must be constructed to fit the farming practice and to give the lowest annual cost possible for its entire life.

The quality and kind of construction carried out in the various parts of the building obviously has much to do with the economical service to be obtained from the structure. Inspection and analysis of hundreds of farm buildings in the Middle West has indicated that failure of the structure, or excessive deterioration, has resulted chiefly from the following causes:

1 Foundations not adequate
2 Failure to anchor sills to foundation
3 Bracing omitted or not adequate
4 Incomplete protection furnished by roof
5 Doors not properly installed.

In addition to these there are, of course, many other contributing causes of lesser importance. By careful attention to the five points listed, however, the appraiser can strengthen his judgment of depreciation rates and building value.

It will be noticed from the list above that joists, rafters, girders, and posts do not ordinarily contribute to excessive rates of depreciation as might be expected. It is found instead that foundations are not constructed of good quality materials; they are not deep enough; there is not sufficient footing under them; or they do not extend high enough above ground. In other cases a good building in most respects is damaged seriously because the sills were not bolted or otherwise anchored to the foundation. Many buildings suffer excessive deterioration because proper bracing was not installed. The collar beams may be lacking entirely or be too light; there may be no brace at the plate; or wind bracing and corner bracing may be omitted. Barns are often poorly braced in the end where the hay mow door is built, and corn cribs are commonly subject to excessive depreciation because a few cross braces were not installed

Incomplete protection to the building because the roof is not adequate is also a common farm building failing. The roofing material may be of poor quality or improperly applied, or the roof may discharge water in storm periods so as to seriously damage the siding, girts, and sills. A little additional expenditure for spouting and gutters and building the foundation about 1½ ft above ground will properly take care of storm water. This will increase the length of life of the building tremendously and decrease annual costs.

Cases where doors are not properly installed also commonly cause excessive upkeep and expense. This is not as important an item as the other four listed above, but, in the aggregate, failure to properly hang the door and limit its

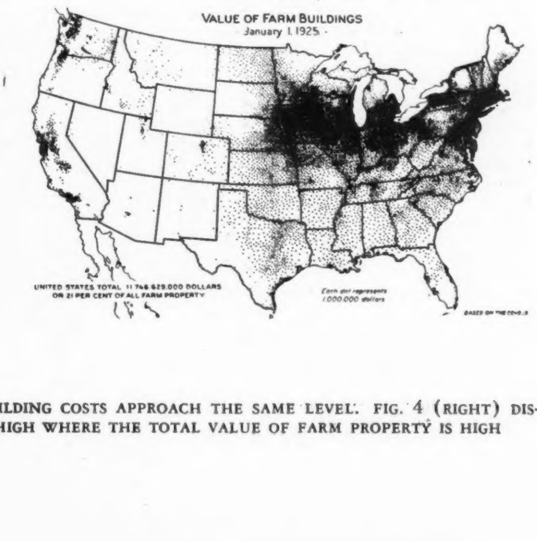


FIG. 3 (LEFT) FARM BUILDING VALUES PER FARM IN 1925. PRESENT BUILDING COSTS APPROACH THE SAME LEVEL. FIG. 4 (RIGHT) DISTRIBUTION OF FARM BUILDING VALUES. FARM BUILDING VALUE IS HIGH WHERE THE TOTAL VALUE OF FARM PROPERTY IS HIGH

motion causes a great deal of expense. Not only is there excessive repair of the door itself but perhaps even more important is the fact that neglected doors allow the weather to speed up deterioration of other parts of the building. All things considered, it is plain that the appraiser can profit much by attention to the structural details of the building when making his choice of rates of depreciation.

There are certain other factors of a general nature that have much to do with making a high utility value in farm buildings. The highest utility value or agricultural value will result when efficient buildings are constructed at the lowest possible cost to the farm owner. This means that not only is a low annual building cost important, but also the initial cost must be as low as possible. A low initial cost has certain important advantages, not the least of which is the reduced credit involved. High first cost of buildings, necessitating in many cases the extension of more credit than the farm owner could meet, has no doubt added much to the difficulties of the farm problem. Why should the present farm owner be required to pay interest on the building investment needed to construct buildings which will be in service half a century after he has left the farm? Even though agriculture is a comparatively stable industry, it is not static, and no building over fifty years old is likely to meet up-to-date requirements and improved farm practices. If comparable, efficient shelter can be secured at a smaller initial cost and equal annual cost, it would seem better to sacrifice something in length of life of the structure. This would have the double advantage of keeping buildings more up to date, and reducing the amount of the first cost owners must meet.

In considering the value that farm buildings add to the land and to the farm as a whole, some study has been given to the investment in buildings per farm and the investment per acre on different sizes and kinds of farms. Fig. 3 gives a picture of the average value of the buildings per farm in the various states. Building value per farm compared with land value may be anything from about one-fourth in Illinois and Iowa to one-seventh as in California, or the building value may be greater than the land value as in several eastern states. Fig. 4 indicates even more clearly than Fig. 3 the geographic distribution of farm building value.

In considering the building investment per acre and per farm, some are inclined to place a maximum building value per acre or to propose that the building value shall not be more than a certain per cent of the total value of the farm. These practices would seem to have little meaning, however, unless confined to a specific size and type of farm. An 80-acre dairy and truck farm may often have a building investment of $100.00 per acre without being overbuilt, and may show a satisfactory income, whereas a grain and livestock farm of 400 acres might well have a building investment of only $20.00 per acre. The appraiser must know the building requirements of the particular farming types in this territory.

The method used by the appraiser in valuing farm buildings is apt to vary somewhat depending upon the purpose for which the appraisal is made. In general, however, it will be desirable and necessary to arrive at the present physical value of the building, and the physical value will be the replacement cost new, less the accrued depreciation. A question immediately arises as to just how much detail is warranted in arriving at the replacement cost. Common practice in estimating building costs varies widely. Some appraisers, for example, estimate the cost of a certain type of barn at, say, $30.00 per *(Continued on page 422)*

TABLE 1. FARM BUILDING VALUATION BASED ON DEPRECIATED REPLACEMENT COST

Building	Description	Cost per sq ft	Cost per cu ft, cents	Per cent depreciation per year: Ordinary limits	Per cent depreciation per year: With average care	Useful life in years: With average care	Useful life in years: Ordinary limits
Barn—dairy and general purpose	Concrete foundation and floor, no fixtures	$0.90 - 1.00	3.5 - 4.5	2.5 - 1.5	2.0	50	40 - 67
Barn—dairy and general purpose	Timber frame, no floor or foundation	0.65 - 0.75	3.0 - 4.0	4.0 - 2.2	3.0	33	25 - 45
Barn—beef cattle and feed	Timber frame, masonry foundation	0.65 - 0.75	3.0 - 4.0	3.3 - 1.7	2.2	45	30 - 60
Barn—beef cattle and feed	Post frame and foundation, metal roof	0.50 - 0.60	2.5 - 3.5	4.0 - 2.5	3.0	33	25 - 40
Barn—hay or tobacco	Timber frame, masonry foundation	0.60 - 0.70	2.8 - 3.6	3.3 - 1.8	2.0	50	30 - 55
Barn—hay or tobacco	Post frame, post foundation	0.50 - 0.60	2.5 - 3.5	4.0 - 2.5	3.0	33	25 - 40
Brooder house	Portable	0.40 - 0.60	7.0 - 10.0	10.0 - 4.0	6.0	17	10 - 25
Cattle shed	Studs and concrete foundation	0.28 - 0.34	3.0 - 3.6	4.0 - 1.8	2.5	40	25 - 55
Cattle shed	Post frame, metal roof	0.20 - 0.28	2.1 - 2.8	4.0 - 2.5	3.0	33	25 - 40
Corn crib, single	Studs, concrete foundation	0.80 - 0.95	7.0 - 9.0	3.3 - 2.0	2.5	40	30 - 50
Corn crib, double or with granary	Studs, concrete foundation	0.65 - 0.70*	4.2 - 5.0	3.3 - 2.0	2.5	40	30 - 50
Corn crib	Post frame, wood floor	0.45 - 0.55	3.0 - 4.0	7.0 - 2.5	4.0	25	14 - 40
Fuel house and wash house	Masonry foundation, wood floor	0.60 - 0.80	5.0 - 8.0	5.0 - 1.8	2.5	40	20 - 56
Garage or small shed	Studs, concrete foundation and floor	0.60 - 0.70	5.5 - 6.5	5.0 - 2.0	3.0	33	20 - 50
Garage or small shed	Post frame, no foundation or floor	0.40 - 0.50	3.7 - 4.7	7.0 - 2.5	4.0	25	14 - 40
Granaries	Concrete foundation, wood floor	0.85 - 0.95	5.0 - 8.0	4.0 - 2.0	2.5	40	25 - 50
Hog house, central	Studs, concrete foundation and floor	0.50 - 0.65	6.5 - 8.0	5.0 - 2.0	3.0	33	20 - 50
Hog house, individual	Portable	0.36 - 0.48	9.0 - 12.0	15.0 - 4.0	8.0	13	7 - 25
House	Not modern or light construction, wood	2.00 - 3.00	9.0 - 11.0	3.0 - 1.5	2.0	50	33 - 67
House	Semi-modern, wood	2.50 - 3.30	12.0 - 15.0	2.5 - 1.2	1.4	70	40 - 83
House	Modern, wood	3.00 - 4.00	15.0 - 19.0	2.5 - 1.2	1.4	70	40 - 83
House	Brick or stone veneer	3.50 - 4.50	17.0 - 23.0	2.0 - 1.2	1.2	83	50 - 83
Machine shed	Studs, concrete foundation	0.40 - 0.50	3.6 - 4.5	4.0 - 1.5	2.3	43	25 - 67
Machine shed	Post frame, no foundation	0.25 - 0.35	2.5 - 3.5	7.0 - 2.2	3.0	33	14 - 45
Milk house	Studs, concrete foundation and floor	1.30 - 2.00	15.0 - 25.0	4.0 - 2.0	2.5	40	25 - 50
Poultry house	Studs, concrete foundation and floor	0.45 - 0.60	5.0 - 7.0	5.0 - 2.0	3.0	33	20 - 50
Poultry house	Post frame, no foundation, dirt floor	0.35 - 0.45	3.5 - 5.0	7.0 - 2.5	4.0	25	14 - 40
Silo	Wood	Cost per ton capacity	$3.00-$5.00	10.0 - 4.0	6.3	16	10 - 25
Silo	Masonry	Cost per ton capacity	$3.00-$5.00	3.3 - 1.4	2.0	50	30 - 70

For ¼ pitch gable roof, add ⅛ width of building.
For ⅓ pitch gable roof, add 1/6 width of building.
For ½ pitch gable roof, add ¼ width of building.
For gambrel and gothic roofs ordinary design, add ⅓ width of building.

*Cribs with overhead granary will run about $0.85 to $1.10 per sq ft.

Inspection and Appraisal of Farm Buildings for Insurance Purposes

By E. D. Anderson, C. H. Frick, and L. G. Keeney

FIRE LOSSES for Iowa, after showing a marked reduction during the period from 1925 to 1928, increased approximately 40 per cent from 1928 to 1931 to a total of nearly $8,600,000. Since Iowa is primarily an agricultural state, the farm fire loss was an important factor in this increase in the total fire waste.

There were several factors responsible for this increase in farm fires. The tremendous drop in farm values and farm prices during this period resulted in a curtailment in expenditures for building repairs. Although postponement of painting was perhaps most noticeable to the casual observer, the failure to repair roofs and chimneys was of real significance as a cause of fires. Lowered income from the sale of farm products also tended to weaken the morale of the property owners and lower the incentive to take the usual precautions to prevent losses. Also the drop in farm value left many buildings overinsured, and, in a few cases, investigation of mysterious fires by the state fire marshal showed that some property owners had attempted to retain their equity in a property heavily mortgaged by "selling out" to insurance companies. In fact, this situation became so acute in some instances that some of the larger companies actually withdrew their protection in certain parts of the country after suffering heavy losses.

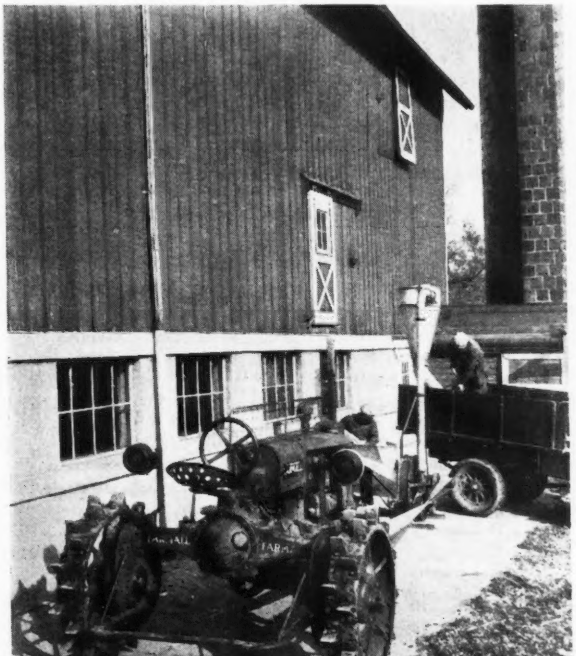
In Iowa at the present time there are 154 cooperative farm mutual insurance companies operating on a countywide basis insuring farm property against fire. At the close of 1935 these companies had a total of over one billion dollars at risk. In size they range from less than one million to over thirty millions of dollars at risk. Reinsurance is provided by the Farmers Mutual Reinsurance Association, an organization formed for that express purpose.

The mounting fire losses, of course, definitely affected these mutual companies. Cutting down of the already low overhead offered little relief, and attention, therefore, was centered upon loss prevention. A survey of the situation made by the reinsurance association indicated that the companies which had been making a careful selection of their risks immediately set out to bring their values into line and to suggest removal of hazards found. Many of the companies, however, reported that their inspectors did not have the proper qualifications and training to make a thorough inspection, and difficulty was encountered in securing compliance with recommendations on the part of their friends and neighbors. The reinsurance association, therefore, filled a definite need when it organized its cooperative inspection service to make available trained inspectors for the use of its member associations.

Because of the frequency and destructiveness of Iowa windstorms, few of the county insurance companies include windstorm coverage in their policies. Most of the agents for these companies are also agents for the Iowa Mutual Tornado Insurance Association, a statewide mutual having approximately $550,000,000 of windstorm insurance at risk. Failure on the part of the policyholder to repair roofs, foundations and broken bracings increased the wind hazard considerably, and made many of the buildings easy prey to windstorms. The tornado insurance association, therefore, was willing and eager to cooperate on the program.

According to the arrangement finally agreed upon, the reinsurance association set up the inspection department. It hires and trains the inspectors and furnishes the necessary supervision. The work is conducted through the office of the county fire insurance company and reports of the inspection are furnished to the policyholder, the local association, the reinsurance association and the tornado association.

The inspection report blank developed is a composite of those commonly found in use. At the local office such essential information as the name and location of the policyholder, the size and age of the buildings insured and the amount of insurance carried is supplied from the application. As an inspection is made, the inspector gives a description of the building construction and state of repair. Space is provided on the blank for computing the insurable value according to the square foot or cubic foot methods, making allowance for depreciation. The various fire and wind hazards found are noted on a check list and a brief description is recorded on the reverse side. Each building is given



FIRE RISK AND REPLACEMENT COST ARE MAJOR CONSIDERATIONS IN APPRAISAL FOR FARM BUILDING INSURANCE PURPOSES

Presented before the Farm Structures Division at the annual meeting of the American Society of Agricultural Engineers, at Estes Park, Colo., June 1936.

Authors: Chief inspector (Jun. Mem. ASAE) and inspectors, respectively, Farmers Mutual Reinsurance Association.

a rating by the symbols A, B, C, etc., to indicate the seriousness of the hazard found.

For convenience the risks are classified into three groups: preferred, accepted, and nonaccepted. An analysis of the state fire marshal's records, made through a research fellowship at Iowa State College, supported by the reinsurance association and the tornado association, was used as a guide in determining the relative importance of the various hazards.

The regulations of the National Board of Fire Underwriters' building code, the national electrical code, and the code for protection against lightning are used as standards of good practice for building construction and installation of equipment. The schedule as devised and applying to the nonaccepted risks is as follows:

NONACCEPTED FIRE RISKS

1 Roof—Wood shingles beginning to weather and curl, unsafe unless spark arrester is installed or building re-roofed in less than 5 years

2 Lightning Protection System—Defects in skeleton system; broken conductor; missing or defective air terminals

3 Heating System—Smokepipe defective or poorly anchored; chimney defective under roof; defects in stove or furnace; safe clearance of heating unit or smokepipe considerably exceeded; thimble required in flue opening in chimney; chimney not accessible in attic—chimney needs inspection

4 Electric System—Wires poorly supported; wires bare in critical places; no fuses, improper size fuses or fuses bridged; open wires covered by trash; system not properly grounded

5 Special Hazards—Auto, truck, tractor or gas engine stored in major outbuilding on combustible floor covered with debris; gas engine exhaust not piped outside building; other hazards of serious nature.

The inspector furnishes his own car and usually is accompanied by a representative of the local association in the field. As equipment, the inspector carries a short folding ladder for use inside the house and a 20-ft ladder made in 6-ft sections for use in reaching the roof of the building. Chimney spark arresters developed through the research project previously mentioned, lightning rod repair parts, flue stops, and fire extinguishers are also included in the equipment carried, to remove as far as possible all hazards found while on the premises. Such follow-up as is necessary is conducted by the local association.

Since the success of the inspection depends a great deal upon the method of handling people, the inspector must be chosen with considerable care. He must have the ability to meet people well and to secure their confidence. He should have a good farm background. Thoroughness is essential, since a poor inspection is worse than none. In most cases, much more is accomplished in securing the removal of hazards by explaining how they may cause fire or wind damage than by the use of force or threats. Such a visit, even though it may be brief, should tend to create a "loss prevention consciousness" on the part of the policyholders.

During the first two years of work, approximately 12,000 risks were inspected in thirty-five counties. Inspection for some associations included only selected risks. Inspectors maintained an average of eight to ten inspections per working day. Cost averaged slightly in excess of $1.00 for each inspection. According to the standards used, approximately 5 per cent of the risks were classed as preferred, 50 per cent as accepted, and 45 per cent as nonaccepted. Approximately 35 per cent of the combustible dwelling roofs and 25 per cent of the chimneys inspected were classed as hazardous. Many electric wiring systems were found to be without fuse protection or improperly fused. Broken ground connections on the lightning protection systems of outbuildings were found frequently. Proper connections to hay-carrier tracks and door tracks were the exception to the rule. However, the associations which have conducted an active follow-up campaign have reported good cooperation on the part of the policyholders in improving their buildings and removing the many hazards found.

The farm insurance agents have always had difficulty in determining the insurable value of buildings. Although books have been published on the subject, few have reached these agents and in many cases the method involved is far too cumbersome to be very useful in making quick estimates. When the inspection service was organized a schedule of cubic foot costs was developed from various sources. This schedule was checked with actual costs of new buildings wherever possible to determine its accuracy. Also wherever possible when inspecting a new building, photographs and complete costs of the building, *(Continued on page 425)*

FARM BUILDING COST DATA

Cost Estimates of Typical Farm Buildings Listed in Midwest Farm Building Plan Service Catalogue

			Per Cent of Total Cost					Cost			Volume Data		Base Area Data	
Plan No.	Building	Size, ft	Foundation	Walls and framing	Roof	Fixtures and hardware	Labor	Materials	Labor	Total	Cubic feet	Unit cost, cents	Square feet	Unit cost, cents
71171	Eight-room farm house	28x30	16.0	34.5	5.0	19.5*	25.0	$3070	$1020	$4090	25,305	0.162	840	4.86
71131	Four-room farm house	24x34	14.0	29.6	6.4	22.4*	27.6	2100	800	2900	17,270	0.168	816	3.55
72112	General-purpose barn	34x60	17.0	36.0	19.0	10.0	18.0	2168	470	2638	56,040	0.047	2040	1.29
72431	Pole barn	52x72	9.5	40.3	26.5	4.0	19.7	1908	468	2376	67,500	0.035	3744	0.632
73221	Corn crib and granary	27x32	19.0	39.8	12.0	8.2	21.0	1127	296	1423	20,100	0.07	864	1.65
73201	Double corn crib	26x32	19.9	38.3	13.7	3.2	24.9	625	206	831	11,640	0.071	832	1.00
72612	Half-monitor hog house	22x42	30.0	25.0	18.5	9.0	17.5	530	115	645	6,823	0.094	924	0.70
72741	Half-monitor poultry house	22x24	24.8	32.7	16.0	7.8	18.7	365	84	449	3,480	0.13	528	0.85
74112	Farm shop and garage	18x24	27.0	25.8	14.3	7.7	25.2	257	87	344	4,752	0.073	432	0.80

*Includes electric wiring, five-fixture plumbing system, and warm air heating system.

Appraisal of Farm Improvements

By E. W. Lehmann

WE SHOULD have a common interpretation of the term "farm appraisal" and the appraisal of improvements. A short definition of an *appraisal* is "an opinion of a fair market price or value."

I do not quite agree with this definition when applied to farm improvements, because the improvement considered may be of a type that could not be sold separately from the farm. In fact, the farm may have been of no value from a production point of view before the improvement was made. If an improvement can be removed without damage to it or without great difficulty or expense, it would have value on the open market separate from the rest of the farm.

The value of improvements in relation to a particular farm is dependent on the need for them, and their use on the farm as a part of a going concern. The use value may be either more or less than the original cost, but the actual or depreciated value is equal to the reproduction cost, if this is not more than its use value, less observed depreciation based on the reproduction cost.

A fair estimate of the value of the improvements on a farm may be somewhere between the seller's and the buyer's subjective valuations. However, the buyer and seller both may err in the same direction as to the true value of an improvement as a part of a production unit.

No appraisal can be better than the judgment of the appraiser, and that is dependent on his training and experience.

Five Considerations. From an engineering point of view, I believe there are five main considerations in appraising farm improvements:

1 The appraiser should have certain special knowledge and abilities which characterize an engineer. I refer to technical information with regard to construction requirements as well as use requirements.

2 The need of, or optimum, improvements on a farm as a going concern, should be the basis for arriving at a fair use value. This is largely a matter of understanding the operating requirements of the farm.

3 The costs of reproducing improvements best suited to the needs of the farm should be determined.

4 Depreciation should be determined by observation, not by the application of an annual percentage reduction.

5 The proper adjustment to determine the true value of a farm should be made by capitalizing the net return from the farm and deducting the difference between the use value and the depreciated optimum value plus other values that are in addition to those affecting the value as a production unit.

To appraise a farm by capitalizing the net returns, using typical yields and assuming a typical operator on soil of known productivity, gives a scientific approach to farm land appraisal. I say this because facts become the basis for the appraisal. Assuming that data and information are available that make this possible, then the greatest opportunity for error in an appraisal is in not recognizing the use and the depreciated value of the improvements on the farm. It is necessary that particular attention be given at this point because the typical farm does not ordinarily have the following:

1 The optimum investment in buildings that are in a state of repair where the use value equals the replacement and depreciated values.

2 A program of soil conservation and improvement that prevents depreciation of the soil productivity, due to soil erosion, and to lack of definite drainage maintenance.

3 A power line.

4 A hard road, or an all-weather road.

5 A modern home, well landscaped.

6 Certain natural resources, as minerals, gravel, limestone, coal, gas, flowing well, and stream for power or use of hydraulic ram.

All of these factors must necessarily be considered in the appraisal of an individual farm.

Use Value Reflected in Net Income. A farm with old, depreciated buildings that have high use value is likely to be appraised too highly by the capitalization method. Therefore, adjustment for depreciation must be carefully made. Since use value of the buildings as a part of a farm production plant is reflected in the total value as determined by the capitalized net return, then a deduction should be made equal to the difference between the use value and the depreciated value. To this should be added the home value that is considered in excess of the home requirements of the farm as a production plant, recognizing that a certain home value is normally a part of a typical farm production plant.

The appraising of farm land in the older countries becomes largely an engineering problem, where the productivity rating and a land use policy have been well established. When the soil productivity ratings are well established for optimum use in this country, the variable factors that I have mentioned, which cannot be determined by a rule, will greatly influence the value of a particular farm.

In considering buildings as a part of a farm, in order to determine the value of the farm, we must consider them as a necessary part of a going concern, the value of which would be included in the capitalized earnings. On the other hand, we must consider them separate from the farm as a production unit, because depreciation may have little effect on use value, but a great deal on actual value.

Factors Determining Value of Buildings. While there are many factors that influence the value of buildings on a farm, which will be outlined later, from a general use point of view there are three considerations: (1) The use value of the buildings in relation to the farm as a primary production plant, that is, in the production of crops. The productivity of the soil is all-important in evaluating a farm from this point of view. However, some buildings are essential. From a production point of view their location may also be important. (2) The use value of the buildings in relation to the farm as a secondary production unit, that is, as a dairy plant, a cattle feeding plant, or a poultry plant. This use value of buildings may be potential if not fully used. (3) The value of the buildings as a place to live.

Presented before the Farm Structures Division at the annual meeting of the American Society of Agricultural Engineers, at Estes Park, Colo., June 1936.

Author: Professor and head of the department of agricultural engineering, University of Illinois. Mem. ASAE.

Attractive barns and outbuildings add to the pride of the occupant and have home value.

Every improved farm has a present use and a different potential use which may represent its highest utility and highest value. It may be in primary, crop production, or in secondary, livestock or dairy production.

Due to rate of depreciation of both land and improvements, the future or potential use may be of reduced utility and reduced value.

Farm land that does not have any buildings, but is farmed from another farmstead, should be capitalized at a higher rate of interest or an amount deducted equal to the normal investment required for such a farm. For example, a 160-acre farm is rented and farmed from a farmstead on a similar 160-acre farm. The total net return from the two farms is $1600. When capitalized at 5 per cent, the value is $32,000, or $100 an acre. The question is, how much is each 160-acre farm worth when considered separately.

The use value of a home may be worth just as much on a small farm as on a large one, but the use value of a crib of 5000 bu capacity is worth only half as much where 2500 bu are to be stored as where there are 5000 bu.

If $32,000 represent the total value of the buildings and 320 acres of land, certainly the 160 acres without buildings would not be worth half this amount less half the value of the buildings, but the 160-acre area would have to be considered as a separate unit and a deduction made representing a value essential to typical production.

Buildings may reflect a value greater than the cost on a large farm, and considerably less than cost on a small farm. For this reason we often hear it said that a farm has been overbuilt. This may be due to high-priced buildings on a large, poor farm, as well as to high-priced buildings, or buildings that are too large, on a small farm.

APPRAISAL FACTORS OTHER THAN USE VALUE

So far I have emphasized use as the important factor in determining the value of buildings. There are many other factors that are also important, some of which are as follows:

1 Condition of the building. In evaluating a building in regard to its condition, I think it might well be rated "A" as being excellent, like new; "B," good; "C," fair; "D," poor; "E," of little value; "F," salvage value.

2 Salvage value. If the building is not needed, its salvage value should determine its actual value.

3 Adaptability to other uses.

4 Cost of remodeling and the value after remodeling are determining factors in arriving at a true value of a building.

5 The permanency of materials and the rate of depreciation, or upkeep, are factors in arriving at a true value of a building.

6 Construction and design are factors that relate to use and life of a structure, and therefore to its value.

7 Efficient arrangement of a group of buildings. The entire group of buildings considered as a whole will have greater value if well arranged for efficient operation.

8 Fire hazards. A poor grade, old shingle roof represents a distinct fire hazard, and will reduce the value of a group of buildings. Proper lightning protection and a good fireproof roof have value in the prevention of fire.

9 The location of the buildings in relation to fields, and also in relation to a market, determines to a certain extent their value.

10 Sanitation and drainage, in relation to health, are important.

11 Sales appeal has certain value in the appraisal of a farm, that is, the general appearance of the farmstead from the highway.

12 The house as a home has distinct value. This, of course, will vary with different individuals. The house may determine the value of a farm when purchased for a home.

13 The surroundings, trees, and general outlook from the house and buildings have a certain amount of value.

Other Considerations. It is evident that there are many kinds of values and those that are recognized and appeal to one individual would not be recognized by another. There is often a sentimental or an esthetic value that cannot be appraised from an economic point of view. An old house may have historic interest because of its design or previous use, which would give it value to a person interested in this sort of thing.

In fact, if buildings are considered only as having economic value, they should be considered as capital goods, and as such their present value would not exceed the present reproduction cost of suitable buildings that would serve the purpose equally well, less depreciation.

From a production point of view, the use value is determined by the need. In many instances change in farm practice may render a building practically useless and therefore of little value, except as it may be adapted to some other use, or its value as material or scrap value.

WHEN USE VALUE EXCEEDS REPLACEMENT COST

Inexpensive or greatly depreciated but adequate buildings may have a much greater useful value to a farm than actual replacement value. Evidence of this is reported in U. S. Department of Agriculture Bulletin 1440. In this study the effect of increased building value on the value of the land per acre was determined. On land with an average value of $170 an acre without improvements, it was worth $190 an acre with $12.50 an acre worth of depreciated improvements, $205 an acre with $25 worth of depreciated improvements, $213 an acre with $37.50 an acre depreciated improvements, and $219 an acre with $50 worth of depreciated improvements. With an increasing value of buildings there was a decreasing effect on the value of the land, until a point was finally reached where an additional investment in buildings did not add more value to the farm.

It has been interesting to note that the decline in farm real estate values during the depression has not seen a corresponding decline in farm building values. This is due largely to the fact that the reproduction cost of buildings, considering material, labor, and transportation, on which the actual value of buildings depends, has not declined at the same rate as the land value. This fact should be kept in mind by the appraiser. It is essential that careful attention be given in each area to determine the useful value of buildings to a farm, which should not be greatly different from the reproduction cost. It should be kept in mind that this value might be considerably more than the depreciated value, which was approximately 20 per cent of the total value of Illinois farms in 1925.

It is evident that the appraiser needs to know what buildings are essential to an efficient and economical production plant. The use value should normally approximate the reproduction cost of such buildings. The depreciated value may be considerably less than this. The scrap or salvage value would be only a fraction of the original cost of the material. These facts are illustrated in the accompanying figures.

In plotting these graphs it is assumed that $25 an acre would provide the house and outbuildings actually needed on a 200-acre farm; this represents present costs to build.

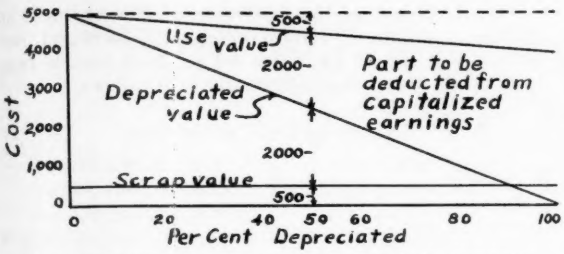


FIG. 1 REPRODUCTION COST AND DEPRECIATION OF BUILDINGS ESSENTIAL TO PRODUCTION

The use value new would be $5000. When appraised, the buildings are found to be 50 per cent depreciated, and yet the useful value as affecting net income is practically the same as when new. It is evident that the difference between the use value and depreciated value should be deducted from the capitalized net earnings.

When there is an additional house on the farm, it should be considered separately from the other buildings. An example would be the case of a second house where the owner lived; a certain value would have to be added as noted in Fig. 2. In this example it is assumed that an equivalent house new would be worth $3,000, and the observed depreciation is 60 per cent.

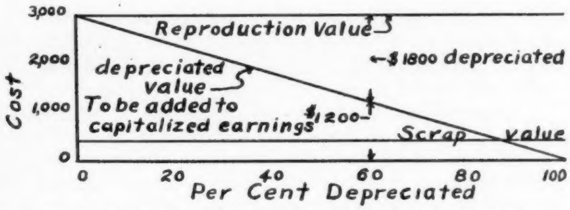


FIG. 2 REPRODUCTION COST AND DEPRECIATION OF EXTRA HOUSE ON FARM

TABLE 1. ANNUAL DEPRECIATION RATES FOR DIFFERENT STRUCTURES*

Description of Building	Range	Average	Mode
Hay and feeding barns—Post frame, no foundation	2.0-12.5	4.04	3.44
Hay and feeding barns — Timber frame, rock or concrete foundation	2.0-2.5	2.20	2.07
Beef cattle barn—Balloon or timber frame, rock or concrete foundation	1.5-5.0	2.44	2.43
Dairy barns — Balloon or timber frame, concrete floor and foundation	1.4-3.4	2.53	1.60
Cattle or machine sheds—No foundation	1.4-5.6	3.20	2.58
Cattle or machine sheds—Balloon or timber frame, concrete foundation	1.1-5.0	2.75	2.44
Garages—Post frame, no foundation	2.0-5.9	3.26	2.60
Garages — Balloon frame, concrete floor and foundation	1.4-4.6	2.66	2.46
Poultry houses — Post frame, no foundation, dirt floor	1.3-11.0	4.05	3.50
Poultry houses — Balloon frame, concrete floor and foundation	1.3-6.6	3.09	2.54
Corn cribs—Post frame, wood floor and foundation	1.3-16.7	3.93	3.48
Brooder houses—Movable	2.1-25.0	5.49	5.56
Individual hog houses	2.3-25.0	7.86	7.50
Centralized hog houses — Balloon frame, concrete floor and foundation	1.6-6.6	3.15	2.51
Granaries—Balloon frame, concrete foundation, wood floor	1.9-3.7	2.56	2.43
General storage houses — Concrete foundation and floor	1.3-6.6	2.63	2.40
Farm houses, not modern, one story	0.9-3.5	1.57	1.28
Farm houses, semimodern, two-story	1.0-2.0	1.55	1.30
Farm houses, modern	1.1-2.0	1.53	1.71

*From Research Bulletin 218 by J. C. Wooley of the Missouri Agricultural Experiment Station.

Depreciation of Buildings. In making adjustment in the value of a farm determined by capitalizing the net income, care must be observed in arriving at depreciation as well as reproduction cost.

Depreciation should be based on observation. A value arrived at by figuring a definite percentage reduction for the age of the building may serve as a guide in an appraisal, but should not be used as the final value. Table 1 is helpful in this connection.

It must be kept in mind that a building 75 years old may be in better stage of preservation that one 25 years old. Its present value may be dependent more on degree of obsolescence than on the state of preservation and repair.

There are many factors that influence the rate of depreciation which might well be observed in making an appraisal. Professor Wooley of the Missouri Agricultural Experiment Station in his bulletin points out the following:

RELATIVE IMPORTANCE OF CAUSES CONTRIBUTING TO FAILURE

	Points of Failure		Apparent Contributing Causes
I	Sills and Connected Framing	1	Lack of care of roof and yard drainage
		2	Foundations too low
		3	Footings inadequate (size or depth)
		4	Inferior or damaged siding
II	Foundations	1	Lack of drainage
		2	Erosion from roof or yard drainage
		3	Inferior design
		4	Poor equality of material
III	Sidings and Doors	1	Lack of care of roof drainage
		2	Failure of sills and framing
		3	Lack of paint
		4	Splice joints not waterproof
		5	Injury by stock or equipment
		6	Inferior workmanship
IV	Roof Covering	1	Inferior quality
		2	Poor selection
		3	Inferior application
V	Roof Trusses	1	Inferior design
		2	Failure of joints
VI	Joists and Girders	1	Overloading
		2	Failure of nailed joints

Professor Wooley found that adequate spouting on barns added 41 per cent to the life. High foundations added 43 per cent. Painting as needed added 43.5 per cent.

Methods of Determining Reproduction Costs. There are two methods of determining the reproduction costs of buildings, one approximate, and the other accurate. The accurate method takes into account all items that are spent in connection with the construction of the building. It is the method which is followed by the contractor in making a bid on a structure where close calculations are necessary. The approximate method is the method that is commonly

used by the appraiser in appraising farm structures. The most common approximate method is to determine the cubical content of the building and multiply the cost per cubic foot times the total volume of the building.

There are other methods of approximating the cost of buildings, that is, estimating on the basis of the number of square feet where buildings are of a uniform type and price. Another method is estimating cost on the basis of the number of rooms in a house or of the number of stalls or pens in a barn.

Where the reproduction cost is determined on the basis of cost per cubic foot, the cubage cost data should be secured locally because of the effect of local prices of materials and local cost of labor on building costs. On account of different roof design, total cubage should be considered rather than the cubic contents to the plate. The following principles should be remembered in estimating the reproduction cost of buildings:

1 Cost per cubic foot decreases as the volume of structure increases.

2 Added height to a certain limit has a smaller effect on total cost than either width or length.

3 Typical larger farm structures cost approximately the same per cubic foot.

4 To estimate accurately for a special location, materials, labor, and transportation costs must be known.

5 Masonry walls do not represent a large proportion of the total cost.

W. A. Foster, of the University of Illinois, made an estimate of the cost of farm dwellings, also barns and similar buildings found on farms for different periods from 1900 up to 1933. This information is as follows:

Estimate of Costs of Dwellings

Frame	1900 to 1915	6 to 10 cents per cu ft
	1915 to 1920	12 to 20 cents per cu ft
	1920 to 1930	25 to 35 cents per cu ft
	1933	20 to 30 cents per cu ft
Masonry	1900 to 1915	15 to 20 cents per cu ft
	1915 to 1920	25 to 35 cents per cu ft
	1920 to 1930	40 to 50 cents per cu ft
	1933	30 to 40 cents per cu ft

Estimate of Costs of Barns and Similar Buildings

Frame	Before 1900	1 to 2 cents per cu ft
	1900 to 1915	2 to 3 cents per cu ft
	1915 to 1920	4 to 5 cents per cu ft
	1920 to 1930	6 to 10 cents per cu ft
	1933	4 to 6 cents per cu ft

Finally, in making an adjustment of the value of a farm as determined by capitalized net income, as far as the buildings are concerned, it must be done on a basis of the difference between use value as reflected in the income and the depreciated value.

Farm Building Costs and Appraisals

(Continued from page 416)

foot length; others may use a figure of $10.00 per foot of perimeter; others may use $1.00 per square foot as the cost, and, finally, many may figure the cost of $0.04 per cubic foot. There is probably no method of cost estimating which is entirely satisfactory. A simple method is always less accurate than a more detailed estimate, but practical considerations limit the amount of detail ordinarily warranted.

A considerable amount of careful study of this problem indicates that the method of cost per cubic foot of volume may be the most practical and satisfactory for most appraisal groups. Cost per cubic foot is commonly used by the building trades and many appraisal groups at this time, and seems to give as accurate results as needed for most purposes. The cubic foot method also permits of more accuracy and flexibility than the other methods mentioned above.

Table 1 has been prepared from the results of a study of costs and inspection data involving buildings on several hundred midwestern farms in 1934 and 1935 and will very closely reflect 1936 conditions. It should be noted that both costs and depreciation rates are for typical and average construction as described in the table and no consideration has been given to unusual design or construction.

Depreciation figures represent average construction given average care. Cases of flagrant neglect will, of course, demand a rate of depreciation in excess of the maximum shown in the table. Straight-line depreciation has been used as most suitable and practical for a farm structure. In general, it will be noticed that buildings smaller than the average will cost near the maximum rate shown in the table whereas buildings much larger than the average will cost near the minimum. In the case of silos, present day average costs are around $4.00 per ton for sizes around 100 tons. Smaller silos will run toward the maximum cost per ton shown in the table and larger ones the opposite. There is little difference in cost between good wood and masonry silos.

In the case of computing the cubic feet of volume in the farm house good quality enclosed porches are figured at full volume whereas open porches are figured at one-half to one-third volume.

In order to more closely fit the conditions of any particular region or territory, this table may be modified somewhat. Once this is done it will then give very good results and periodic percentage revisions in unit costs may be made to follow cost trends. In general, however, it will be found that the careful use of the table will give the experienced appraiser a very close estimate of present day replacement costs of typical farm buildings in the middle west.

It should be pointed out that in using the table the column of costs per square foot should be employed with some caution. Square foot costs will be valuable only for very rough approximations if the size and type of building varies much from the average. The costs per cubic foot will give considerably closer estimates of replacement costs and this method will fit a wider variety of sizes and types of farm buildings.

The information on costs and depreciation incorporated in this table can not be adopted as a universal or fool-proof measuring stick of replacement costs of farm buildings, because there is, after all, no substitute for experience and good judgment in appraisal work. The table will, however, serve as a guide to contemporary replacement costs in the middle west, and, more important, it will serve as an example of the kind of valuation table which can be set up to insure more uniform and more systematized appraisal.

Farm Building Valuation as Related to Long Term Loans

By A. E. Backman

THIS PAPER is not intended to deal with the minutia of building valuation, but rather to point out various factors that bear on the subject and their effect in the consideration of long term loans. By long term loans I have in mind farm mortgage loans for periods of from ten to thirty-three years, made through the federal farm loan system now represented by the Farm Credit Administration, with particular reference to the Federal Land Bank of Berkeley, serving Utah, Nevada, Arizona, and California.

The statement has been made that for several years past farm homes and farm buildings all over America have steadily been "going down hill" for lack of care and attention. The trend in this direction considering the stress of the times is not surprising, but it is to be hoped that reversal of this trend, which is now in evidence in many areas through the assistance of both private and governmental agencies, will maintain and ultimately result in raising the standards of farm building improvements.

Farmers are not alone in welcoming a degree of prosperity which will make possible the adequate maintenance of existing farm improvements and the replacement of old or obsolete structures for modern effective buildings. Credit agencies exemplified by private individuals, local banks, life insurance companies and government-regulated institutions which have financed farmers through both long and short term loans, are vitally interested.

Presented before the Farm Structures Division at the annual meeting of the American Society of Agricultural Engineers, at Estes Park, Colo., June 1936.

Author: Engineer-appraiser, Federal Land Bank of Berkeley (California). Assoc. Mem. ASAE.

CONDITION, USE VALUE, AND INSURANCE PROTECTION ARE MAJOR CONSIDERATIONS IN APPRAISAL OF BUILDINGS FOR LOAN PURPOSES

The value assigned to farm building improvements in the United States represents a tremendous investment. The 1930 census shows this value to total $12,949,993,774.00, which is approximately $2000 per farm, or roughly one-third the value of all farm land. In the four states served by the Federal Land Bank of Berkeley the total farm building valuation as determined by the 1930 census is, in round numbers, $524,000,000, which is an average of about $2900 per farm, and roughly one-seventh of the value of the farm land. Aside from other considerations, it is apparent that farm building improvements have a security value which is of considerable importance in programs of farm financing.

Most farm buildings can be classified either as homes, or shelters for livestock and equipment, or as storage buildings for crops. Their relative importance is manifestly dependent upon the type of farm enterprise. Thus in certain grazing sections buildings on the land are not indispensable to profitable operation. In some dry farm areas buildings may be limited largely to storing grain and housing machinery and equipment, with no living quarters provided. Specialized farming calls for building construction peculiar to the enterprise. For example, an excellent dairy farm may be operated by a renter or by hired labor, with dwellings confined to tenant houses and the major construction centering in dairy barns and milk houses. If owner operated, more adequate living quarters are expected. Generally speaking, the home is of paramount importance, and in many sections without dwellings and other building improvements, farms are unacceptable as security for land bank loans.

While the major proportion of funds advanced to borrowers is used for liquidating indebtedness, the bank is frequently called upon to consider loan applications where the loan proceeds are to be used for building improvements. Such use of funds is considered a laudable purpose. It is recognized that good farm buildings make for a more contented existence, particularly when combined with facilities available to city dwellers. Moreover, a properly balanced building set-up within reasonable economic limits in the long run should result in increased efficiency of farm operations.

The federal land bank favors sound building programs. By and large, farm properties with desirable economic building improvements are less likely to become problem cases for a loaning institution. In the event a particular operator becomes badly delinquent, there exists a better opportunity for him to sell with a possibility of some salvage. If foreclosure results, a credit agency, similarly through better opportunity for sale, is less likely to experience a loss in its investment.

The federal land banks function under certain limitations with respect to loaning operations. The Farm Loan Act passed by Congress in 1916 stipulated that loans granted to farmers should not exceed 50 per cent of the value of the land mortgaged and 20 per cent of the value of the

permanent insured improvements thereon, said value to be determined by appraisal. Moreover, the act further provided that in making said appraisal the value of the land for agricultural purposes should be the basis of appraisal and the earning power of said lands should be a principal factor.

Under the provisions of the Emergency Farm Mortgage Act of 1933 a special fund was provided for the granting of so-called commissioner loans on first and second mortgaged securities. Loans up to 75 per cent of the normal agricultural value of the farm were authorized with a maximum loan established at $5,000, which was later changed to $7,500. It then became possible to grant a land bank loan based on 50 per cent of the normal agricultural value of the land plus 20 per cent of the permanent insurable buildings, and in addition a second mortgage commissioner loan in an amount such that the total of the two loans would not exceed 75 per cent of the normal agricultural value of the farm. Where farm set-ups were not eligible for land bank loans, the full 75 per cent loan became available on first mortgage security.

Limiting loan value on building improvements to one-fifth their permanent insured value would ordinarily be considered as conservative procedure. It became apparent, however, that, in the segregation of farm enterprises into land and insurable building improvements, allowable loan values in many cases would permit of excessive loans. In harmony with the provisions of the Farm Loan Act which made the value of the land for agricultural purposes the basis of appraisal, the banks quite uniformly placed a similar construction with respect to building improvements. Accordingly, loan value on building improvements was determined from the value of such permanent insured buildings to the farm as established by the appraiser.

With the inauguration of the commissioner type loans it became increasingly important to make careful appraisals, since it became possible to grant 75 per cent loans. It is encumbent on the land bank appraiser to determine the normal agricultural value of the farm he inspects. Such value has been defined as "the amount a typical or average farmer for the area and type of farm would be willing and could afford to pay for property for strictly agricultural purposes if he obtained normal prices for products of the farm." Manifestly, in this determination, the building improvement side of the farm set-up is given careful consideration.

In this connection the appraiser is required to report as to the value of all building improvements, such appraisals to be based on replacement value less depreciation. He must report the kind, dimensions, type of construction, condition, and age of these buildings, and indicate which are uninsurable and which are permanently insurable. The bank requires the borrower to insure buildings designated by the appraiser as permanently insurable, to 60 per cent of their appraised value for a regular land bank loan and to 75 per cent for a commissioner type loan. It is therefore important that the appraiser discuss insurance requirements with the applicant. Where he objects to carrying insurance on structures not absolutely essential to the farm enterprise, the appraiser has been instructed to list such building improvements as uninsurable, thereby precluding any loan consideration.

Having set up the value of permanent insurable buildings, the appraiser is charged with the important duty of determining the value of these buildings to the farm, arising from their use in connection with farm operations. Buildings cost money. Too often farmers desiring loans point to their heavy investment in the farm as a logical justification for substantial loans. In many cases building value far exceeds the value of the land and constitutes a major portion of the owner's investment in the farm. Obviously a careful determination of the value of such buildings to the farm is a prerequisite of sound loaning policy.

It is necessary for the appraiser to consider many factors germane to this problem. No fixed rules apply. In the first place, he must bear in mind that long term loans are predicated on the ownership and operation of farm securities by the average farmer. He must, therefore, determine whether building improvements represent a prudent investment from the standpoint of the average farmer in the community and the type of farm. He should accept a standard in buildings which the farm unit will reasonably support and community standards justify. An overbuilt farm is like an overcapitalized business, and, while possibly not a deterrent to successful operations by the exceptional farmer, is certainly a liability to the average farmer or to the borrower who may be below average.

Buildings that are needed and suitable in size and cost should be worth to a farm their normal replacement value, less depreciation. Exceptions may occur in cases where farm structures feature in an enterprise not common to the area. Thus a dairy set-up in a fruit section, where the stability of a dairy venture is questionable, would likely call for discounting building value to arrive at an appropriate value to the farm. Moreover, in a portion of the bank's loaning territory the social system has evolved rural communities which function as headquarters for farm operations as well as for social and business activities. In some areas buildings on the farm are rare, most farmers preferring to center all building construction on their town properties. Where these conditions obtain, farms having building improvements may be but little more desirable, as reflected in sale price, than those farms devoid of such improvements. Hence the value to the farm of these structures, as established by the appraiser, is likely to be much less than their appraised value.

Loan applications must frequently be considered upon farms located in areas where tenant farming is the rule rather than the exception. Such areas may have undergone a transition wherein farming by landowners has gradually changed to farming by renters. Building improvements that once were desirable and economic for the owner-operator may not now be suited to the tenant, or may be considerably above the standards of the buildings common in the neighborhood. Here again the appraiser will likely show a value to the farm materially less than the actual appraised value of the insurable buildings.

As of April 30, 1936, the Federal Land Bank of Berkeley, for itself and as agent of the land bank commissioner, had in force 38,115 loans. This represents a loan on about one farm out of every five in the four states of the eleventh land bank district, based on the 1935 federal census of agriculture. No statistics are immediately available as to the extent to which farm buildings feature in the security value behind such loans. As an indication of the relationship between land value and the value of building improvements to the farm, the results of an analysis of land bank loans in one of the better counties of Utah and California, may be of interest. In both cases general farming predominates, although poultry, dairying, truck gardening, and fruit growing are important. As of March 15, 1935, out of 379 land bank loans on farms in the Utah county having building improvements. the average building value to the farm was $1,850 and the average appraised value of the land per farm was $6400, or a ratio of 29 per cent. In the California county, out of 944 loans on farms having building improvements, the corresponding value was $2,500 and $8,300, respectively, with a ratio of building value to the farm and appraised value of land equal to 30 per cent.

The land banks, being essentially cooperative institutions operating for the benefit of farmers, are directly affected by the vicissitudes of their farmer borrowers. Neglect of land or building improvements may ultimately result in a loss to the banks in case of foreclosure, which in turn reacts to the detriment of the farmer stockholders. On the other hand, ill-advised expansion in the way of purchase of additional land or construction of buildings may result in financial embarrassment to the borrower.

Generally speaking, a vast field exists in justifiable farm building expansion and rehabilitation of existing structures which offers excellent opportunity for agricultural engineers. Credit facilities were never more favorable. While admittedly the promotion of farm building improvement is highly desirable, judicious construction and choice of buildings should be closely followed.

There is definite evidence of activity in many rural areas in building rehabilitation and in new construction. The time is propitious for consolidating the progress already made, and in furthering additional sound development. Improvement in agricultural conditions is just as basically important as improvement in an industrial field. The agricultural engineer in this connection contributes his share in research and active technical direction and advice; schools provide reservoirs of knowledge and experience; credit agencies extend financial assistance with low interest rates which are unprecedented; the government now goes to greater lengths to assist agricultural recovery than has ever before been attempted; business in general is coming more to a realization of the interdependence with agriculture. Upon the farmer, the recipient of benefits and losses, subject to the vagaries of markets, pest inroads, and weather conditions, must be placed the responsibility of continuing progress. I have faith in the efficacy of cooperation and the ability of the farmers to carry on. Greater agricultural stability will be achieved.

Inspection and Appraisal of Farm Buildings for Insurance Purposes

(Continued from page 418)

together with a description of the type of construction, were obtained.

Cost estimates of a number of typical farm buildings listed in the Midwest Farm Building Plan Service catalogue have been made. The material and labor prices used have been checked in various parts of the state, and the cost estimates have been found to compare favorably with similar buildings actually constructed. (See schedule below.)

Experience of the inspectors in the field has shown the cubic foot method somewhat more cumbersome than the square foot method and no more accurate. For that reason, the table opposite, using the latter method has been prepared and is proving very useful in appraisal work.

The appraisal method used for determining the insurable value of the building consists first of determining the present replacement cost new, selecting the unit costs from the table opposite. Then the many factors affecting depreciation, such as state of repair and obsolescence, must be considered. The value of the building in relation to the value of the farm in some cases will limit the amount of insurance to be carried, as will the moral hazard. Fair appraisal for insurable values perhaps requires the greatest experience and most sound judgment of any of the duties of an inspector.

Although the true worth of this program of loss prevention on farms can be measured only by a comparison of the loss experience over a period of years, the immediate reports of reduced losses and of a general "loss-prevention consciousness" on the part of the farmers has been very gratifying, and the continued demand for this service is indicative of a favorable attitude on the part of the insuring public.

SCHEDULE OF PRINCIPAL MATERIAL AND LABOR PRICES USED IN ESTIMATES

Material Costs:

Items	Per thousand board feet
Dimension lumber 2x4-in and 2x6-in, 10 to 16 ft	$50.00
Sheathing No. 2 common	45.00
Shingles, No. 1 red cedar	5.00
Car siding No. 1 common	58.00
Cribbing No. 1 common	55.00
Barn siding, 1x12-in, No. 2 pine	55.00
Cement per sack	0.70

Unit Labor Costs:

Roof, including placing of rafters, sheathings, and shingles	$3.15 per square
Walls—barns, cribs, etc.	$ .06 per sq ft
Walls—dwellings, including labor in finishing	$ .18 per sq ft
(NOTE: All wall areas including partitions are used)	
Concrete, including labor for trenching	$2.00 per cu yd
Excavation	$ .60 per cu yd

The unit labor cost interpreted in terms of hourly wages is as follows:

Common labor per hour	35-40 cents
Carpenter labor per hour	50-55 "
Mason labor per hour	55-60 "
Plasterer labor per hour	55-60 "

Prices effective May 1, 1936

TABLE FOR ESTIMATING REPLACEMENT COST NEW OF FARM BUILDINGS

	Average cost in dollars per square foot of ground floor area
DWELLINGS:	
1-story frame, not modern	$2.50
1½-story frame, not modern	3.00 to 3.25
2-story frame, not modern	4.00
1½-story frame, modern	4.00
2-story frame, modern	5.00 to 5.50
BARNS:	
Hay barn, frame, concrete footings, 8-ft studs	
1500 to 2400 sq ft	0.60
2400 to 3000 sq ft	0.45 to 0.50
For each additional foot of wall height add	0.02
General-purpose, frame, 16-ft studs	
Concrete footings	1.00 to 1.15
Concrete foundation, concrete floor	1.25 to 1.35
Completely modern	1.45
CORN CRIBS AND GRANARIES:	
Double crib, frame	
Masonry piers, plank floor	0.75
Concrete foundation, plank floor	1.00
Concrete foundation and floors	1.10 to 1.20
With overhead granary, concrete foundation and floors and shelling trench	1.50 to 1.60
SHEDS:	
Cattle or machine, frame	
Post construction	.045 to 0.50
Concrete foundations	0.55 to 0.60
POULTRY AND HOG HOUSES:	
Post construction	0.50
Frame, concrete foundations	0.65
Frame, concrete foundations, concrete floor	0.75
GARAGES AND SHOPS:	
Frame, concrete foundation, concrete floor	0.80

Experimental Design of Vertical Drop Culverts

By H. B. Roe

THE widespread interest of the past few years in the soil erosion problem has sharply stimulated research in soil erosion control measures. Among these elimination of gullies by use of soil-saving dams holds a prominent place. An essential feature of the soil-saving dam is the vertical drop culvert which lets the water by while enabling the retention, above the dam, of the eroded material which finally fills the gully. As there were not available definite data on which to base efficient and economical design of such culverts, means were sought early in 1931 for carrying out the necessary research for supplying the desired information. To this end a cooperative agreement was entered into between the departments of hydraulics and of agricultural engineering of the University of Minnesota. The studies herein presented were the outcome of this cooperation. They were carried out at intervals during 1931, 1932, and 1933. The final analysis was completed in January 1934.

The literature of hydraulics offers little contribution to the problem, but there are some of related interest to which attention is directed.

In 1906-07, C. B. Stewart[1] investigated flow of water through short, submerged tubes of square cross section four feet on a side, with axis horizontal and in lengths from 0.31 to 14 ft. He especially studied type of entrance and evolved a discharge formula of the usual form in terms of velocity-head ($Q = Ca\sqrt{2gh}$), and a diagram for determining the capacity of such tubes. The coefficient of discharge, C, for the specified cross section only, changed with length of tube and type of entrance. Hence the formula is generally applicable only by selection of the coefficient C by interpolation.

In 1924-26 D. L. Yarnell, F. A. Nagler, and S. M. Woodward, in cooperation with the U. S. Department of Agriculture, Bureau of Public Roads[2], investigated the flow of water through pipe culverts 30.6 ft long, axes approximately horizontal and with various types of wall and shapes of entrance. They evolved formulas for each type of the general form

$$Q = KD^xH^{0.5}$$

in which Q = discharge in cubic feet per second, K is a coefficient dependent on the kind of pipe and shape of entrance, D = diameter in feet, x is an exponent also dependent on the kind of pipe, and H = total head, in feet, on the culvert, or the difference in water level between the two ends of the culvert.

Extension of these formulas to pipe culverts of *any length* resulted in a formula for each type, of the general form

$$Q = \frac{A\sqrt{2gH}}{\sqrt{1 + KD^x + \dfrac{K'L}{D^y}}}$$

in which Q, H, and D are as in the general formula previously stated, A = area of cross section of the pipe in square feet, L = length of pipe in feet, and K and K', and x and y are coefficients and exponents dependent on the kind of pipe and the shape of the lip at entrance.

A formula was also evolved for box culverts similar in form to the one above stated in which the diameter, D, is replaced by the hydraulic radius, R.

The results of the two series of investigations thus far discussed have been used effectively to meet the ordinary culvert requirements of railroad and highway practice. Capable and eminent engineers of the author's acquaintance extend the use of these formulas to the case of culverts with vertical-drop inlets. These men contend that governing conditions and resulting hydraulic action are the same except for the head loss due to the bend or elbow leading from the vertical to the horizontal member which is readily provided for as a special term in the statement of Bernouli's theorem written for the specific case.

The author believes that application of any general culvert formula to the case of the vertical drop inlet is not the best practice, because such application fails to give full and proper consideration to the peculiar distribution of pressure at or near the entrance—especially where the vertical member is re-entrant—to the effect of the free vertical fall on head losses, and to greater tendency to open vortex which entrains much air and consequently results in greatly increased internal pressure and loss of head.

Paper presented at the annual meeting of the American Society of Agricultural Engineers at Athens, Georgia, June 17 to 20, 1935. Approved as Journal Series Paper No. 1437 of the Minnesota Agricultural Experiment Station. Abstract of a thesis submitted to the faculty of the graduate school of the University of Minnesota in partial fulfillment of the requirements for the degree of master of science in civil engineering, March 1934.

Author: Professor of Agricultural Engineering, University of Minnesota. Mem. ASAE.

Acknowledgments: The author is indebted to his chief, Professor William Boss of the Division of Agricultural Engineering, University of Minnesota, whose keen interest in the general problem helped to make possible the cooperative arrangement. The author, however, acknowledges an especial indebtedness to Dr. Lorenz G. Straub, director of the hydraulics activities of the University whose patient interest, wise counsel, and liberal expenditure of time upon the problem alone made possible the successful consummation of these studies.

[1]Stewart, C. B. (1908) "Investigation of Flow through Large Submerged Orifices and Tubes." University of Wisconsin Bulletin No. 264, Eng. Series, Vol. 4, No. 4: 249-332.

[2]Yarnell, D. L., Nagler, F. A., and Woodward, S. M. (1926) "Flow of Water through Culverts." University of Iowa Bulletin No. 1, New Series 103, Studies in Engineering.

SYMBOLS USED

a = area of cross section of the tube in square feet
d = diameter of tube in feet
G_h = flume hook gage reading
G_p = point gage reading on headwater
G'_p = point gage reading on lip of tube
g = acceleration of gravity
H = head on lip of tube in feet
H_w = head on 90-degree triangular weir
h = total lost head at outlet of tube
h_1 = value of h when $H = 1$
K = calibration constant between point gage and flume hook gage
$k = h_1/d$ when $d = 1$
Q = discharge in cfs
ϕ = Froude's number (v^2/dg or $0.050408\ Q^2/d^5$)

Ford Kurtz[3] clearly recognized this problem when he worked out his design for a vertical shaft spillway for the Davis Bridge Dam near Whitingham, Vermont, in 1924. In spite of severe criticism of his design by various eminent engineers, after careful perusal of Kurtz's exposition and his rebutting discussion the author feels that the kernel of the design is sound especially as far as the circular converging crest weir and the vertical sections of the spillway are concerned. On account of its flaring type of entrance Kurtz's design is largely outside the scope of this paper which is concerned only with that type of vertical drop culverts circular in cross section and with straight sides clear to the lip of the tube. Furthermore, the economic feasibility of such a design as that offered by Kurtz, applied to any ordinary case with relatively little water and supplied only by occasional freshets of limited duration, may be called into question in comparison with the slight additional cost of a larger size of simple culvert with straight sides at the crest and of sufficient capacity to handle peak floods with safety.

However, entrances of the converging weir type with pierlike additions on the lip to control the direction of flow and aid in checking vortex should be seriously considered for the bellmouthed type of entrance. The photographic evidence alone, presented by Kurtz, of the efficacy of the ring of radially located bridge piers in prevention of vortex and in increase of capacity is sufficiently convincing to warrant considerable faith in the method. In this connection the second conclusion by Kurtz is significant. It reads as follows: "The problem of the reduction in the capacity of the shaft spillways due to the entraining of air is not a serious one if proper methods of design are followed."

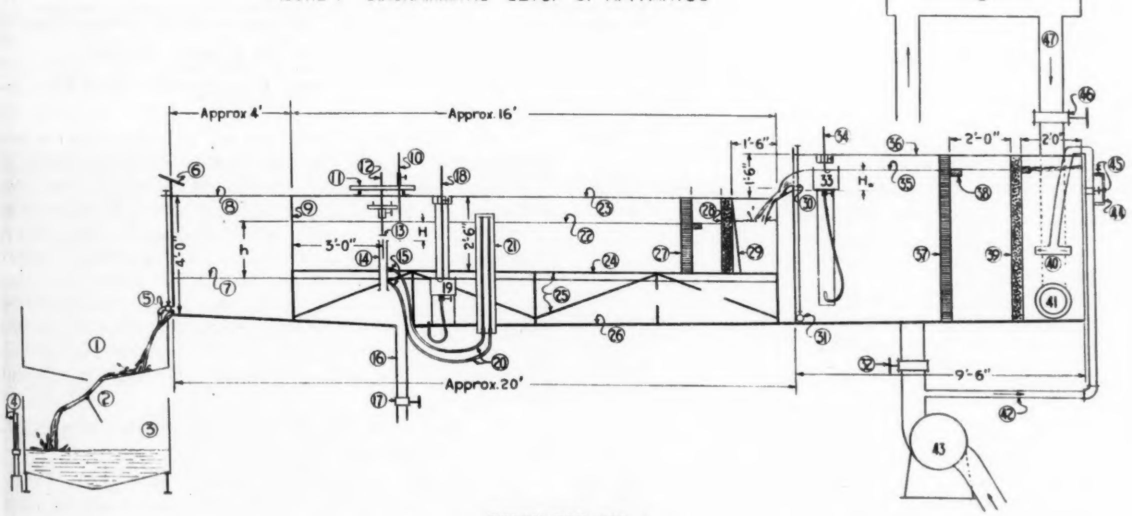
In the tests discussed in this paper, entraining of air through open vortex always resulted in such sudden and large increase in loss of head as to be plainly visible to the naked eye in the form of sudden rise in the headwater level. In order, therefore, that this problem shall not become a serious one in practical installations, it seems desirable that especial stress be laid upon the conditions for its elimination implied by Kurtz in the words "proper methods of design."

The nearest approach to the immediate problem of this discussion in current literature seems to be the work of F. E. Lawrence and P. L. Braunworth[4] on "Fountain Flow of Water in Vertical Pipes." By a well controlled series of experiments and by mathematical analysis of the experimental data by a method somewhat similar to that employed by the author in the present investigations, these men arrived at a law of jet flow, vertically upward through pipes, similar in general form to that which would result from solving the author's equation [10] for the discharge (Q) vertically downward. There is this marked difference, however, that the principal *head factor* in the author's equation [10] is that of lost head, whereas in the law of upward jet flow as given by Lawrence and Braunworth the only *head*

[3]Kurtz, Ford (1925) "The Hydraulic Design of the Shaft Spillway for the Davis Bridge Dam and Hydraulic Tests with Working Models"—with discussions. Trans. Am. Soc. C. E., Paper No. 1551, V 88: 1-86.

[4]Lawrence, F. E., and Braunworth, P. L. (1906) "Fountain Flow of Water in Vertical Pipes"—with discussions. Trans. Am. Soc. C. E., Paper No. 1035, V 57: 265-306.

FIGURE I DIAGRAMMATIC SETUP OF APPARATUS



INDEX FOR FIG. 1

1 Collecting hopper
2 Tipping bucket
3 Weighing tanks
4 Weighing scale
5 Two-inch, fine-control gate valve
6 Plank gate lift
7 Typical tailwater level
8 Top of main concrete flume
9 Experimental tank end
10 Point gage
11 Point gage frame
12 Ratchet rod
13 Circular brass plate
14 Experimental tube
15 Piezometers
16 Four-inch drain
17 Four-inch drain gate
18 Flume hook gage
19 Stilling basin for flume hook gage
20 Pressure tubes connecting piezometers with manometer
21 Manometer
22 Typical headwater level
23 Top of experimental tank
24 Bottom of experimental tank
25 Timber support to experimental tank
26 Floor of main concrete flume
27 Streamline baffles (corrugated metal strips)
28 Gravel baffles for control of turbulence
29 Loose wooden baffle
30 Triangular weir notch
31 Drain gate to supply basin
32 Eight-inch gate valve
33 Stilling basin for weir hook gage
34 Weir hook gage
35 Typical water surface in supply basin
36 Top of main supply basin
37 Streamline baffles (corrugated metal strips)
38 Wooden floats for stilling turbulence
39 Gravel baffle for control of turbulence
40 Secondary supply outlet
41 Main supply outlet
42 Two-and-one-half-inch secondary supply line
43 Pump
44 One-inch by-pass for fine control
45 Supply control gates
46 Eight-inch main supply control gate
47 Main supply pipe
48 Gravity supply tank
h Total lost head
H Head on lip of tube
H_w Head on weir notch

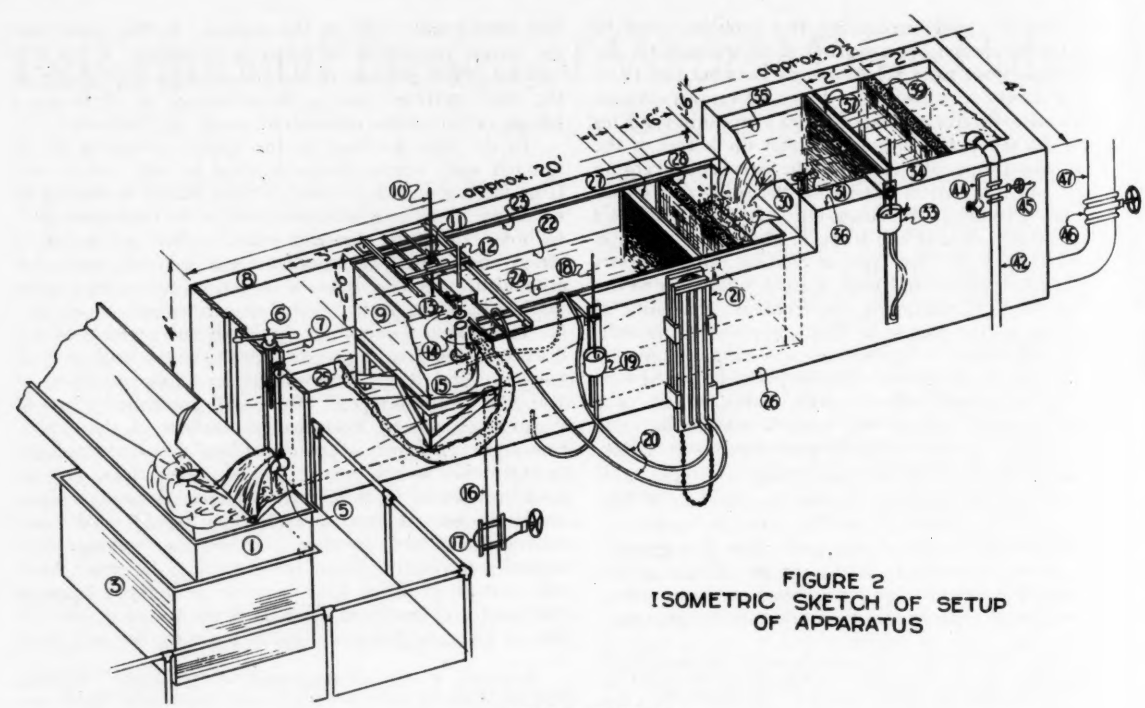


FIGURE 2
ISOMETRIC SKETCH OF SETUP OF APPARATUS

INDEX FOR FIG. 2

1 Collecting hopper
3 Weighing tanks
5 Two-inch, fine-control gate valve
6 Plank gate lift
7 Typical tailwater level
8 Top of main concrete flume
9 Experimental tank end
10 Point gage
11 Point gage frame
12 Ratchet rod
13 Circular brass plate
14 Experimental tube
15 Piezometers
16 Four-inch drain
17 Four-inch drain gate
18 Flume hook gage
19 Stilling basin for flume hook gage
20 Pressure tubes connecting piezometers with manometer
21 Manometer
22 Typical headwater level
23 Top of experimental tank
24 Bottom of experimental tank
25 Timber support to experimental tank
27 Streamline baffle (corrugated metal strips)
28 Gravel baffle for control of turbulence
30 Triangular weir notch
31 Drain gate to supply basin
33 Stilling basin for weir hook gage
34 Weir hook gage
35 Typical water surface in supply basin
36 Top of main supply basin
37 Streamline baffle (corrugated metal strips)
39 Gravel baffle for control of turbulence
42 Two-and-one-half-inch secondary supply line
44 One-inch by-pass for fine control
45 Supply control gates
46 Eight-inch main supply control gate
47 Main supply pipe

factor is head on the crest (H). These men offer two slightly different formulas as follows:

Where the heads on the crest were measured by the more exact method of the Pitot-tube, $Q = 5.84H^{0.53}D^{2.025}$.

Where the heads were measured by the cruder method of sighting rods, $Q = 5.57H^{0.53}D^{1.99}$.

A closer similarity than that already noted can hardly be expected as the case of fountain flow is the reverse of that of downward discharge through a vertical pipe. The first works against gravity, the second with it, and the conditions of approach to the mouth of the tube are different in the two cases.

THE PROBLEM

Scope. The experimental work on this problem and all the accompanying analyses and discussions in this paper are confined to circular tubes with straight sides clear to the entrance section, with axis vertical, and with entrance section horizontal and of the exact size of that of any other horizontal section of the tube.

Character. The most efficient condition is that in which the entrance section is completely filled with the flowing water. Then capacity of the inlet will increase with the increase in head upon it. Therefore, there is, theoretically, no major limit to capacity except that imposed by the height of the dam holding back the water and causing a head on the inlet, or of the crest of the spillway over or around the dam. If, then, local conditions are such that flood waters must not be permitted to spill over the top of the dam, an important consideration is the design of some device that will limit the head that may build up to an elevation safely below the crest of the dam. The minor limit of efficiency is reached when conditions of head become such that a vortex is formed, air breaks through, and the full flow as an orifice is transformed into flow as a weir. The transformation occurs at relatively low heads on the inlet. Any device that will retard the formation of a vortex without also unduly increasing the lost head will increase the range of efficient discharge.

The solution of the problem then, briefly summarized, involves the following steps:

1 *Discharge in Tailwater* (outlet submerged). Determination of the total lost head at the outlet section on a sufficient number of sizes of inlet and for a sufficient number of values of discharge to enable the formulation of the general mathematical relationship between discharge, diameter of inlet, head on the lip, and lost head.

2 *Discharge in Air.* Determination of the head formed on the entrance section for each of a sufficient number of values of discharge and of diameters of inlet to enable the formulation of the general mathematical relationship between discharge, diameter, and head on the entrance section.

The physical limits of the laboratory set-up in this study did not permit development of sufficient head on the lip of

the tube to cause it to run full when discharging freely in air. As such a limitation would reduce the case of free discharge in air to that of a special case of discharge through a horizontal orifice, it has no significance relative to discharge through culverts. Hence further discussion of this case will be omitted from this paper.

3 *General Features.* (a) Determination of an effective method for preventing formation of vortex; (b) determination of an effective method of limiting the height to which head will develop for any given set-up.

Phase (b) of the problem is untouched in the present study except in so far as it is directly concerned only with the elimination of vortex occurrence through the use of the plank float hereinafter described and illustrated in Fig. 4 (*e* and *f*).

PHYSICAL SET-UP FOR EXPERIMENTAL TESTS

(See Figs. 1, 2, and 3)

1 *The Main Experimental Flume.* The main experimental flume is one of the two permanent concrete flumes on the main floor of the hydraulic laboratory. It is 30 ft long, 4 ft wide, and 4 ft deep to the springing line of the floor, and it is fitted with a 4-in drain controlled by a gate valve.

The supply basin is a portion of the main flume $9\frac{1}{2}$ ft long, partitioned off at the pump end and having its walls built up to a height of 18 in above the walls of the main flume to furnish a head of water above the experimental tank.

The remaining 20 ft of the experimental flume serves as a tailbay. Setting in it, supported by a strong timber trestle resting on the floor of the main flume, is the experimental tank representing the pool or forebay above the dam.

2 *The Experimental Tank.* This tank is of 20-gage galvanized iron reinforced throughout with angle iron. It is 15 ft long, 42 in wide, and 30 in deep, the top of its wall being very nearly up to the level of the top of the wall of the main flume and its rear end set near enough to the triangular weir to receive the discharge from the supply basin without loss. In its floor is set the experimental vertical culvert or tube later discussed.

3 *Source of Water.* The source of water was the sump in the hydraulic laboratory. Water was furnished to the experimental supply basin by two electrically driven centrifugal pumps which gave an ample supply for the maximum capacity of the experimental inlets. Steady flow was assured by a large storage tank at the top of the second story of the laboratory. From this the water supply could be drawn under constant head unaffected by the pulsations of the pumps.

4 *Control of the Water Supply.* Control of the supply of water delivered to the experimental apparatus was secured by the customary methods through the use of gate valves. One system, fitted with a $2\frac{1}{2}$-in gate valve and a 1-in by-pass with gate valve for fine adjustments, led direct from the pumps to the experimental apparatus. The other system led direct from the storage tank to the experimental apparatus and was controlled only by an 8-in gate valve. The latter, although more difficult of fine adjustment, once adjusted to a given discharge was much the more satisfactory because unaffected by the pulsations and variations of the pumps.

5 *Measurement of Water Supply.* Measurement of the supply of water furnished was by means of a 90-deg triangular weir, cut in a brass plate $\frac{1}{8}$ in thick fastened securely and water tight in the forward wall of the supply basin. The zero of the weir notch is set approximately 6 in above the top of the experimental tank. The notch of the weir is ample to supply the maximum amount of water required in the tests. The head on the notch is measured by a hook gage connected with the supply basin. The weir was carefully calibrated at the beginning of the work and discharge from it in excess of 0.1400 cfs (cubic feet per second) was found to conform, within practical limits, to the formula

$$Q = 2.46\ H^{2.48}$$

For values of Q lower than 0.1400 cfs the rate of discharge was determined by weighing the amount of water dis-

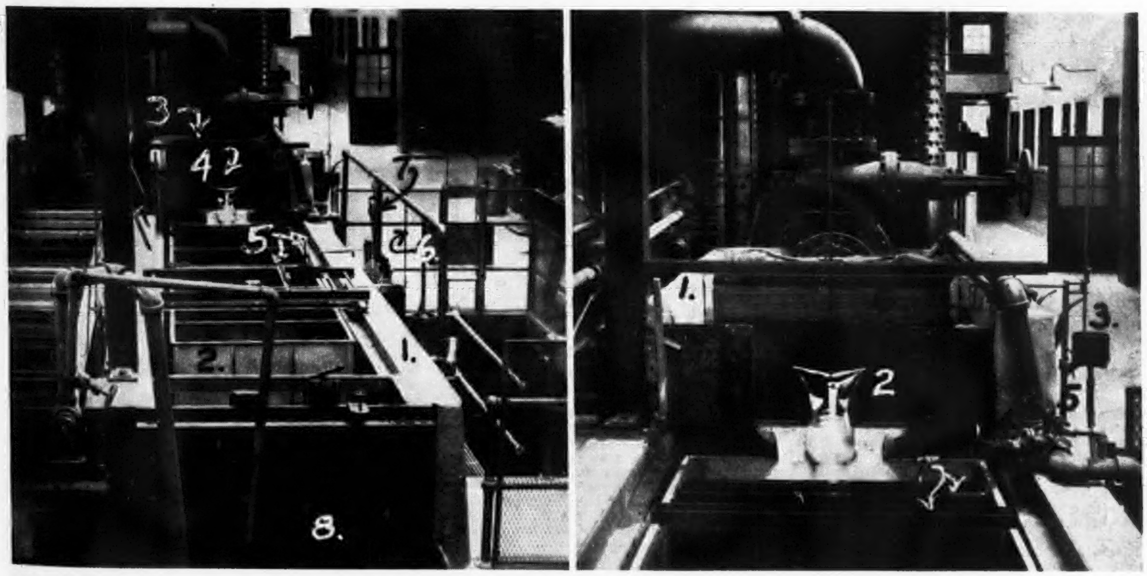


FIG. 3 VIEWS IN THE HYDRAULIC LABORATORY SHOWING THE EXPERIMENTAL SET-UP

(Left) General view: (1) Main flume, (2) experimental tank, (3) supply basin, (4) triangular weir, (5) point gage and carriage, (6) flume hook gage, (7) manometer, (8) tailwater outlet. (Right) Close-up of supply unit: (1) Supply basin, (2) triangular weir, (3) weir hook gage and stilling basin, (4) gate valve of secondary supply line, (5) small by-pass and gate, (6) baffles in supply basin, (7) baffles in experimental tank

charged in each run during a period of time accurately measured by a stop watch.

6 *The Drop Culvert or Tube.* The center of this tube is set 3 ft from the end of the experimental tank farthest removed from the triangular weir and in the center of the tank transversely. The tube has a 9-in circular disk base by which it is bolted to the floor of the tank, the joint being made watertight by a rubber gasket backed above and below by wrought iron rings. The base is supported under the tank by an iron bridle resting on the concrete floor of the main flume and fitted with setscrews for *plumbing up the tube.*

7 *Sizes of Tube Used.* Tests were made with three sizes of experimental tube as follows:

	Inside diameter, ft	Length in Feet above floor of tank	Length in Feet below floor of tank	Total	Total length in diameters
Large size	0.3046	1.0000	0.6875	1.6875	5.54
Medium size	0.2029	0.6667	0.4650	1.1317	5.58
Small size	0.1393	0.4210	0.3082	0.7292	5.23

The large tube was of 22-gage galvanized iron rolled into a perfect cylinder with a soldered butt joint and machined ends.

The medium tube was of seamless copper spun to specified dimensions of 22-gage thickness when finished and with machined ends.

The small tube was a commercially drawn seamless tube of brass. The outside at the top end was turned down to a 22-gage thickness for a distance of about two inches. The end sections were machined to an exact right section as in the case of the other two sizes.

It was at first determined, arbitrarily, to use tubes in the different sizes outletting in every case at the floor of the experimental tank. However, piezometers in the large and the medium tubes at approximately one-half diameter above the bottom of the tank and connected with a manometer showed many noticeable and rapid fluctuations of pressure, so that it was concluded that the tube did not always run full at the base of the tank even at steady flow

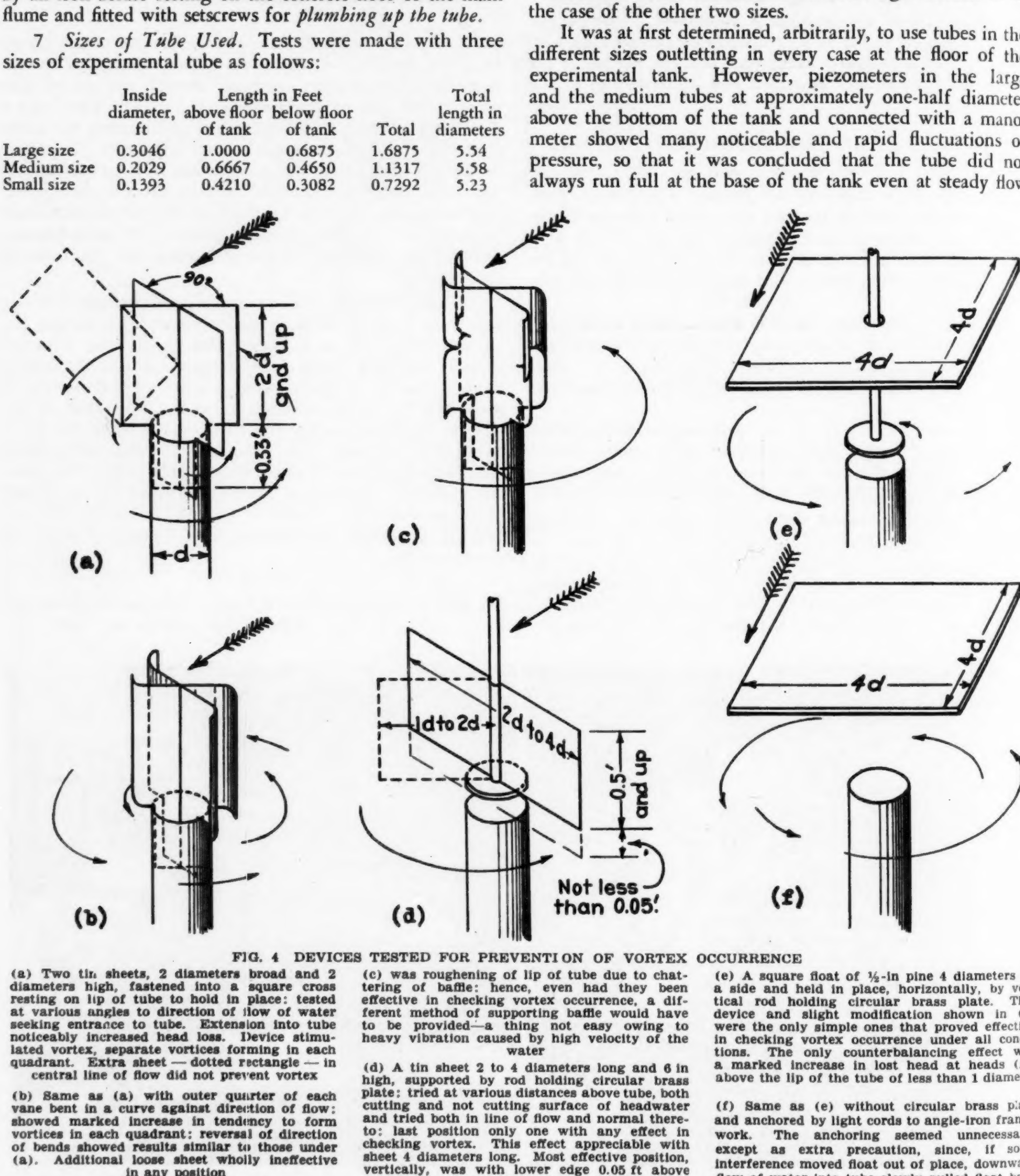


FIG. 4 DEVICES TESTED FOR PREVENTION OF VORTEX OCCURRENCE

(a) Two tin sheets, 2 diameters broad and 2 diameters high, fastened into a square cross resting on lip of tube to hold in place: tested at various angles to direction of flow of water seeking entrance to tube. Extension into tube noticeably increased head loss. Device stimulated vortex, separate vortices forming in each quadrant. Extra sheet — dotted rectangle — in central line of flow did not prevent vortex

(b) Same as (a) with outer quarter of each vane bent in a curve against direction of flow: showed marked increase in tendency to form vortices in each quadrant: reversal of direction of bends showed results similar to those under (a). Additional loose sheet wholly ineffective in any position

(c) Same as (b) except that lower half of each vane is cut from upper half and bent in opposite direction. General results same as (b). One undesirable effect common to (a), (b), and (c) was roughening of lip of tube due to chattering of baffle: hence, even had they been effective in checking vortex occurrence, a different method of supporting baffle would have to be provided—a thing not easy owing to heavy vibration caused by high velocity of the water

(d) A tin sheet 2 to 4 diameters long and 6 in high, supported by rod holding circular brass plate: tried at various distances above tube, both cutting and not cutting surface of headwater and tried both in line of flow and normal thereto: last position only one with any effect in checking vortex. This effect appreciable with sheet 4 diameters long. Most effective position, vertically, was with lower edge 0.05 ft above lip of tube. Lower increased head loss: higher reduced effectiveness: relation to water surface immaterial. Extra sheet, normal to main vane, without influence. This baffle impractical for large culverts

(e) A square float of ½-in pine 4 diameters on a side and held in place, horizontally, by vertical rod holding circular brass plate. This device and slight modification shown in (f) were the only simple ones that proved effective in checking vortex occurrence under all conditions. The only counterbalancing effect was a marked increase in lost head at heads (H) above the lip of the tube of less than 1 diameter

(f) Same as (e) without circular brass plate and anchored by light cords to angle-iron framework. The anchoring seemed unnecessary, except as extra precaution, since, if some interference moved float out of place, downward flow of water into tube slowly pulled float back into place again. Device would be handled readily in practical cases as it could be anchored to the screen posts around the inlet by light steel cables or chains

and with a constant value of Q. On this account an additional length of approximately two and one-quarter diameters was added below the floor of the tank in each case. A piezometer inserted in this extension, one diameter up from the outlet, in the case of the two larger tubes, indicated practically steady pressure. It was, therefore, concluded that, under conditions of steady flow, the tubes ran full at a section one diameter above the outlet and, therefore, also at the outlet section. The projection below the floor of the tank had the added advantage that the tailwater completely submerged the outlet without danger of bubbles of air being trapped against the floor of the experimental tank and so affecting the internal pressure in the base of the tube, as was apt to occur when the outlet was in the plane of the bottom of the tank.

In the early stages of the work piezometers were also set approximately at the contracted section and at sections one and a half and two and a half diameters below the lip of the tube. It was hoped to use the pressure readings obtained by means of these piezometers to determine a distribution of pressure, longitudinally of the tube, that would enable a complete analysis of head losses. However, a large number of readings in each case showed such uncontrolled fluctuations as to render them of no experimental value beyond the general conclusion stated in the preceding paragraph. The disturbances and general lack of reliability were undoubtedly due, in large part, to the fact that they registered only peripheral pressures which were liable to be rendered extremely variable by friction against the sides of the pipe and by internal turbulence from other causes beyond control. The final conclusions then with regard to these readings agreed with those made by Lawrence and Braunworth[4] who state, "It was found that a tap in the side of a vertical pipe was utterly inadequate for indicating heads."

8 *Plates above the Mouth of the Tube.* A rigid frame of angle iron is fastened across the top of the main flume, with a plate, ratchet, and clamp key directly over the tube. Through the plate passes a brass pipe $1/2$ in in diameter with a ratchet race on one side. A circular brass plate, the exact diameter of the inside of the tube, may be screwed on the bottom of this pipe. By means of the ratchet and clamp this plate may be set at any desired height above the mouth of the tube. The purpose of the plate is to try to avert the formation of vortex and to increase the discharge for any given head.

9 *Experimental Devices for Preventing Vortex Occurrence.* Some device effective in checking vortex occurrence is essential if high and intermediate values of head, H, on the lip of the tube are to be held steady for a given Q and at given stages of tailwater. Such control is necessary in practice to prevent overtopping of dams by sudden rises in headwater elevation caused by entraining of air, consequent on vortex formation, increasing the internal pressure. Various forms of sheet-metal baffles were tried out to this end and the results obtained with these various forms are indicated on the face of Fig. 4. Neither the plate nor any of the various sheet-metal baffles tried proving generally effective, finally a square wooden float, four diameters of the tube on a side, was installed directly over the tube. This float was held loosely in place by cotton twine attached to each corner and tied to the adjustable plate frame above. The dimension of four diameters was fixed upon because it was noted that, when vortex formed and moved about the tube, it tended to move in circles about the axis of the tube as a center, and that the maximum diameter of this circular orbit was approximately four diameters of the tube. The float gives the needed control and the increase in lost head resulting from its use at *low* stages of headwater is practically immaterial as it is the higher heads that are of real concern in this type of problem. No serious loss of head is caused by the use of the float at high and intermediate stages of headwater. To determine whether or not this is so a few series of runs under the same conditions, otherwise, were made both with and without the float and no appreciable differences were obtained. Furthermore, without the float, at such stages as that just stated, it was very difficult to obtain a full series of readings uninterrupted by vortex. At low heads of approximately one-half diameter, however, the float did cause appreciable loss of head; but it should be borne in mind that, without the float, vortex was sure to occur at these low heads with a much greater resultant head loss.

10 *Devices for Measuring Levels of Tailwater and Headwater.* The main flume is provided with a hook gage set as shown in Figs. 1 and 2.

The experimental tank is provided with a point gage supported on an angle iron frame set across the concrete walls of the main flume and so constructed as to permit of leveling up at any time. The gage is fastened to an auxiliary frame supported by the main frame and so constructed as to permit of moving in any horizontal direction within limits ample for the general range of the apparatus. The total possible transverse movement of the point gage is the full width of the main flume so that it is possible to permit the gage to clear the sides of the experimental tank and reach the surface of the tailwater in the main flume. This arrangement permits of a very exact calibration of the flume hook gage and the point gage, because both gages can be read at the same instant with both set at the surface of the tailwater.

11 *Control of the Discharge of Tailwater.* The discharge end of the main flume is fitted with a plank bulkhead in which are inserted two plank gates capable of being made watertight and one of them adjustable, by means of a bench-vise screw, to any desired discharge. For fine adjustment of tailwater level, there is a standard 2-in gate valve with a long-stemmed handle placed alongside of the adjustable plank gate.

12 *Baffles for Control of Turbulence.* In both the supply basin and experimental tank two baffles are placed as shown in Figs. 1 and 2. The first of each of these pairs, counting from the supply end, is of gravel, purely to retard turbulence. The second in each case is a streamline baffle of strips of finely corrugated sheet metal stacked upon each other with flat strips between to keep the corrugations open. These latter baffles very effectively rectify the direction of flow.

By means of these pairs of baffles aided by board and plank floats behind the baffles to quiet the surface, velocity of approach, both in the supply basin back of the triangular weir and in the experimental tank, is practically eliminated.

13 *Weighing Tanks.* The tailwater from the main flume is discharged into a large collecting funnel or hopper from which it flows into one of the weighing tanks on the floor below through a tipping bucket. This tipping bucket enables the operator to reverse the flow at any instant from one weighing tank to the other, thus permitting duplicate weighings without delays. The capacity of each of these tanks is ample to handle a ten-minute discharge at the highest rate used in any of the tests.

GENERAL EXPERIMENTAL MANIPULATIONS

The zero of notch of the 90-deg triangular supply weir having been determined and the weir calibrated by standard procedure, the next necessary step was the calibration of the point gage of the experimental tank with the hook gage of the main flume and hook gage with the manometer scale. The methods were as follows:

1 *Calibration of Point and Hook Gages.* With all gates closed as tightly as possible the experimental tank and main flume were filled with water to a height recordable by all gages. Small leaks in the gates in the early stages of the work prevented absolute quiet, but a sufficient time was allowed to elapse, before gage readings were taken, to reach a condition as near rest as possible. Then, with three operators working in unison, several sets of readings of all gages were taken each gage being read instantaneously on signal. The averages of ten to twenty sets of readings gave equations between the gages well within our guiding limit of error of 0.5 per cent.

2 *Calibration of Manometer with Hook Gage.* The manometer was calibrated with the main flume hook gage as follows:

The apparatus being nearly filled with water, the water was allowed to settle at an extremely low rate until the reading of the surface passed a definite full foot on the hook gage and, at the same instant, a definite foot on the manometer scale was adjusted to coincide with the surface in the manometer tube. This process was repeated several times and finally checked by absolutely quiet conditions. When, for example, the water surface in the manometer tubes stood at 1.000, with the surface by hook gage standing exactly at 2.000, this point was marked with a knife edge on the manometer board and other settings of the board required by different heads were measured from this point.

Necessary changes in the apparatus and unavoidable disturbances of the fixed equations between gages made necessary recalibration of all gages whenever such disturbances occurred. The results of all such calibrations are introduced into the tabulated results as shown in the tables.

3 *Determination of Elevation of Lip of Tube.* This was done with the point gage. It was early found that the buoying effect of the tailwater at different stages of tailwater and the twisting and warping of the plank support of the experimental tank were sufficient to cause serious raising and lowering of the entrance section of the tube even during single series of observations, and that it was thus also constantly thrown out of level. To overcome this an adjustable iron bridle resting on the concrete floor of the main flume was installed. The portion of the floor of the experimental tank holding the experimental tube rested securely upon the top of this bridle without other support. Leveling screws in the base of the bridle enabled exact leveling of the entrance section of the tube and maintaining it in a fixed position. A mechanics spirit level was then placed, centered, across the lip of the tube along a diameter and the point gage was read resting on top of this level at each extreme end. This operation was then repeated with the level in a second position at right angles horizontally to the first. The depth of the level frame being carefully determined by micrometer caliper, the exact elevation of the lip of the tube was then known from the point gage readings taken on the top of the level.

SOME ESPECIAL LIMITATIONS

1 *Values of Q.* With each size of experimental tube series of tests were run to determine the lost head with each of three values of Q established as standard for the purpose of these tests as follows:

Q Standard	Large Tube	Medium Tube	Small Tube
High	0.6005 cfs	0.2034 cfs	0.1060 cfs
Medium	0.4110 cfs	0.1503 cfs	0.0825 cfs
Low	0.2034 cfs	0.0825 cfs	0.0648 cfs

2 *Tests With and Without Plate.* In the early stages of the work for each Q class a number of preliminary tests were run with the large and also with the medium tube, both without the plate, and with the plate, ¼, ½, ¾, and 1 diameter above the lip, in order to determine the general effect of the plate. These tests showed that the plate had little if any effect in checking vortex, while, on the other hand, it did increase head loss over that occurring with the same set-up except without plate, approximately as follows:

Distance of plate above lip of tube	Per cent increase in h over same case without plate	Notations
Plate up 1 diameter	0 to 2½	According to Q and d values
Plate up ¾ diameter	1½ to 2	According to Q and d values
Plate up ½ diameter	2 to 10	According to Q and d values
Plate up ¼ diameter	27 to 86	According to Q and d values

Therefore, in final tests with all three tubes, the only position in which the plate was used was that of ½ diameter above the lip of the tube, and that only to complete the general line of attack and to present evidence of the character just mentioned. Thus 18 sets of tests were run in all, that is, one with and one without plate for each Q class with each of the three tubes.

However, even the case of the plate ½ diameter above the tube, because of its evident lack of practical value was disregarded in all later discussions of the data, and only the nine sets of data without plate were used in the final mathematical developments and summing up.

(To be concluded in November issue)

Preventing Silo Gas Accidents

BECAUSE of the possible presence of suffocating gases soon after silage has been stored, entering a silo is considered dangerous at that time.

The greatest danger comes when large quantities of carbon dioxide gas are generated during the fermentation that always takes place when corn ensilage is placed in the silo. This fermentation, which begins immediately after the ensilage is put in, may continue for several days. The excess amount of carbon dioxide often lowers the oxygen content of the air to such a point that persons entering the silo will suffocate.

The pit silo, with its lack of ventilation, is the source of greatest danger. The air in the above-ground silos may be regulated by keeping one of the many doors open near the surface of the silage. Care should be taken to open the doors as near the silage level as possible after it has had time to settle.

The presence of dangerous gases may be detected easily by lowering a small animal or fowl into the silo before anyone enters. If the atmosphere is dangerous the animal or fowl will be affected but may be revived when brought back into fresh air. No attempt should be made to enter the silo until the gases have been removed by agitating the air or by proper ventilation.

Natural Drying of Forage Crops

By T. N. Jones and L. O. Palmer

BASED on the percentage of each present, it might well be said of the green forage crop that it gives a good yield of plant moisture containing approximately 30 per cent solid matter which is the nutritive part of the crop. Mention is made here of this fact, not merely as a play on words, but in the hope that the agricultural engineers of this country may be made aware of the magnitude and importance of the problem with which we as engineers are confronted in the natural dehydration of forage crops.

The training and experience which we have received for, and in, our particular field of work has been of such a nature as to direct our thinking along the line of artificial dehydration with only a slight trend toward a consideration of the natural processes involved. The practice of artificial drying is fascinating to the average person and especially so to the farmer. The possibility of cutting, curing and storing his hay crop within a fraction of a working day makes the process attractive to the farmer, even with the enormous expense involved. To say that this procedure is fascinating to the men who have been trained both in agriculture and engineering would be a mild statement of the fact. The problem at once lends itself to the application of Btu's required per pound of water evaporated, and as such laws are the chief claim for the existence of the engineer, we welcome the opportunity to put them into practice. Notwithstanding the fact that some members of this vocation have brought credit to themselves and to the profession by their meritorious work on this particular problem, our haste to apply only engineering principles to the solution of all problems has very often brought upon us the just criticism of being narrow-minded and obstinate.

As previously stated, much credit is due the men and institutions who have developed the artificial hay driers. These machines have served and will continue to serve the large producer who markets a high grade product and does not use his hay as a low-cost livestock feed. But with the six million farms in this country averaging only 60 acres of harvested crops per farm, only a very small percentage of the owners can afford to even pool their capital in an artificial drier that will cost $1500 to $5000 and then require $4 to $10 per ton of hay as fuel cost, with their present thermal efficiency. Thanks are due the Tennessee Valley Authority for their interest manifested by building a $300 electric drier, but paying for the 200 to 450 kilowatt-hours required per ton of cured hay is still an unsolved problem to the average farmer.

The builders of artificial driers have set up requirements for successful driers as follows:

1 Low initial cost
2 Simple operation and control
3 Low power consumption
4 Simple design and low maintenance cost
5 Provide hay having food value, color, aroma and palatability
6 Reduce the moisture content to a predetermined amount low enough for storage
7 Power to take care of average acreage and to keep power, labor and overhead charges within economic limits.

Of these factors, the low initial cost and low power consumption have not been achieved. We are hoping that these may some day be realized so that even the average farmer can dry his hay artificially at a reasonable cost, but until then, we must help him with the problem of curing his forage by natural means. By natural curing as treated in this paper is meant any method of handling the hay whereby the sun is the sole source of heat for driving off the excess moisture contained in the forage plants.

The proper stage for cutting most hay crops is just prior to maturity. At this time they have just passed through the period of most rapid growth and are very succulent, since the newly formed cells and tissues have not yet hardened with the consequent decrease in moisture content to form the reenforcing structure for fruit support. There is in the living plant at this time a continuous stream or mesh of water, the molecules of which are within and between cells from the deepest root tip to the edge of the uppermost leaf

Presented before the Power and Machinery Division at the 30th annual meeting of the American Society of Agricultural Engineers, at Estes Park, Colorado, June 1936.

Authors: Respectively, agricultural engineer. (Assoc. Mem. ASAE) and assistant agricultural engineer, Mississippi Agricultural Experiment Station.

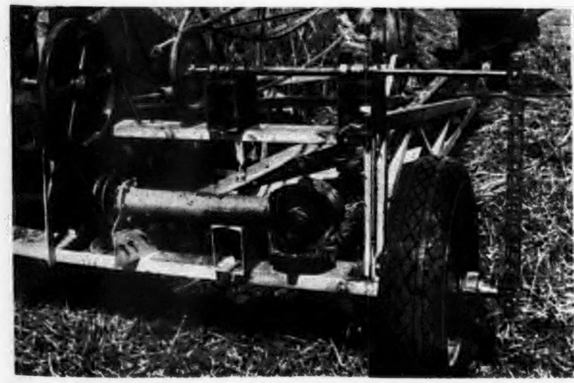


FIG. 1 (LEFT) THE MISSISSIPPI MOWER-CRUSHER, SHOWING THE DRIVING MECHANISM AS ATTACHED TO THE TRACTOR. FIG. 2 (RIGHT) FRONT VIEW OF DRIVE, SHOWING CANVAS AND CRUSHING ROLLERS

or shoot, and from the pith to the corky bark or surface of the stem. This water enters the plant through the root hair and is drawn upward through the entire plant system, finally passing out through the leaves in the form of vapor into the surrounding atmosphere. This process of transpiration under favorable conditions causes a movement of the water stream upward through the plant of at least two inches per minute. Thus, within a very few minutes, an hour at most, the water entering the root hair will be escaping from a stomatal pore of an uppermost leaf.

If plants cut for hay could be so handled as to preserve or promote this natural flow of plant moisture, the process of natural dehydration would defeat for all time the hazards presented by the time element. So far our efforts coupled with the work of the plant physiologist have been only partially successful. By enlisting the help of plant physiology at the Mississippi Agricultural Experiment Station, the agricultural engineering department has been able to obtain results which enable us to establish fundamental explanations for the characteristic behavior of certain plants in curing, and also give us a lead toward formulating other methods of field handling to hasten the natural process of drying.

PHYSIOLOGICAL BEHAVIOR OF PLANTS AFTER CUTTING

For instance, we have found by double-windrowing alfalfa hay with a side-delivery rake two hours after cutting that hay with a moisture content of 18.5 per cent may be obtained within eight hours. A study of stomatal behavior on this hay revealed the fact that the stomata reopen following windrowing, thus allowing for a freer passage of the water. The stomata close rather rapidly in the swath and the rate of moisture loss is thereby retarded considerably; so much so that the direct exposure of the plant parts to the open air and sunshine does not remove the water from the plants as rapidly as from those within windrows. Also the hay is bleached of some of its green color by the sun, and if allowed to remain in the field over night, there is a greater leaching of chlorophyll due to the condensation and action of dew. The greater loss of leaves from hay cured in the swath may be accounted for by the uneven drying of leaves and stems, thereby causing the abscission layer at the base of the petiole to rupture and the leaf to fall from the stem. The protection of the leaves from the parching action of the sun seems to greatly reduce the shedding and consequently makes a much better grade of hay. In addition to the superior quality of product obtained, the more rapid rate of moisture loss from the hay double-windrowed two hours after cut is of prime importance and is explained physiologically in previous articles appearing in AGRICULTURAL ENGINEERING[1].

It was found at the Mississippi Station that the stems of alfalfa, Johnson grass and soybeans would lose but 10 to 20 per cent moisture within a day's time when stripped of their leaves as the plants were cut. This result clearly indicates that the leaves offer the most favorable outlet for the plant moisture and also gives a fairly definite index as to the impervious nature of the stem wall and the resistance offered to the radial passage of moisture out of the stem.

When the plants are cut for forage, the higher percentage of moisture is contained in the leaves and younger stems from whence evaporation continues rather rapidly. If the forces operating to supply the moisture to them from the lower stem could still continue, all would be well and the crop would soon be sufficiently dry for storage, but such is not the case, and the curing process is a long one, encountering all the hazards of weather and causing the farmer to sustain a greater loss from this crop than from all other crops he raises.

The natural forces responsible for the passage of water through living stems are:

1 Capillarity and imbibition
2 Osmotic pressure of living cells in the roots and along the stems adjacent to the chief conducting elements, xylem and phloem
3 The pull of transpiration assisted by the cohesive forces within the water.

It would seem that only the forces of capillarity and imbibition and the transpirational pull could[1] be even partially active in the cut plants as the osmotic pressure of living cells adjacent to the conducting tissue is definitely out of the picture. The forces of capillarity and imbibition can work only slightly since they are dependent upon a renewal of the water supply to the successive group of cells from which the water is released. As the moisture content of the inner tissues is reduced, the surface tension of the film surrounding each cell becomes greater and the capillary or imbibitional movement must be very slow at best. However, the exact pull exerted and the importance of these forces in the water loss from cut plants has not been accurately determined.

THE NATURAL DRYING FORCE WHICH RESPONDS TO ENGINEERING CONTROL

The transpirational pull of the leaves, or the cohesion theory, is regarded by physiologists as the most logical and plausible explanation of the ascent of sap in the living plant, and it would seem to be the most important natural force in removing the water from the cut plant. If the stomata remain open, the water will evaporate from the moist cell walls adjoining the stomatal chamber and pass into the surrounding atmosphere. This results in incipient drying, or a saturation deficit in these cavities, the menisci becoming more concave and their surface tension materially increased. As a result of this behavior, water is drawn from the protoplasm and vacuoles of adjoining cells to again bring about equilibrium upset by this transpiration. This causes a similar disturbance in the protoplasm of the adjoining cells and in the final analysis a pull approximating 200 atmospheres is exhibited in the water system of some plants. This force is based entirely upon the cohesive action and tensile strength of the water column or network within the plant system. Just how long it is possible for it to be in effect after the plant is cut is still in doubt. As the cut end of the stem dries, there would be a downward pull due to the forces of imbibition and capillarity that would tend to counteract the transpirational pull, and as drying advances further, the tensile force will probably be sufficiently great to break the continuity of the water stream which naturally slows down this process considerably. Such influences as these coupled with the two forces just mentioned, together with others not yet determined, are responsible for the flattening out of the curve on the rate of moisture loss after the first few hours of curing.

The role of the engineer and physiologist in speeding up the curing process is chiefly to control environmental conditions favoring a continuation of the natural functions of the plant for as long a period as possible after the cutting of the hay. The environmental conditions favoring evaporation from the living plant such as: (1) open stomata, (2) high temperature, (3) free movement of air and (4) low relative humidity, may not be the most favorable for transpiration from (Continued on page 437)

[1] "Field Curing of Hay, as Influenced by Plant Physiological Reactions," by T. N. Jones and L. O. Palmer, AGRICULTURAL ENGINEERING, August 1932 (Vol. 13, No. 8), June 1933 (Vol. 14, No. 6), and June 1934 (Vol. 15, No. 6).

The Dehydration of Farm Products

By F. E. Price

DEHYDRATION of farm products has become quite common with several commodities, particularly on the Pacific Coast. Sun drying of fruits, such as peaches, prunes, apricots, and raisins, has been practiced in California since their establishment in that state. Walnuts were also sun-dried for many years in California.

Artificial dehydrators for various crops have been in use 70 years or more. Hop driers were in use in California as early as 1866. In 1879 there were 304 acres of hops grown in Oregon which were artificially dried. The early type of hop drier with the kiln floor 12 to 18 ft above the ground has continued to be used since that time, with relatively few changes until the last six years. Nearly all of the early dehydrators were built to operate by natural draft. Consequently they did not use power. As greater consideration was given to increased output per drier, fuel efficiency, and the quality of the dried product, forced draft driers were developed for all crops requiring dehydration. With this development of dehydrators some crops continued to be sun-dried and others changed to artificial drying. While most of the prunes are still sun-dried in California, practically all of the walnuts are artificially dried. In Oregon and Washington all of the prunes and walnuts are artificially dried.

This form of processing has developed until it now maintains a position of considerable importance in the handling of farm products. Table 1 gives a tabulation of the tonnage of walnuts, filberts, prunes, and hops which are grown annually in the three Pacific Coast states, and which are now dependent entirely upon artificial dehydration for preparation for market. The cost of drying per ton is also given for these various crops. The operation of these dehydration plants requires large expenditures for labor, consumes large quantities of wood and oil for fuel, and with the predominance of forced draft driers in recent years, requires hundreds of horsepower to operate the fans.

TABLE 1. TONS OF FARM CROPS DEHYDRATED ON THE PACIFIC COAST

	Oregon	Washington	California	Total	Drying cost per ton	Total drying cost
Walnuts	2,240		40,100	42,340	$10.00	$423,400
Filberts	733			733	8.00	5,864
Prunes	22,340	3,381	206,000*	25,721	30.00	771,630
Hops	9,092	3,117	4,200	16,409	32.00	525,088

*Mostly sun dried—not in total.

It was about 1920 that prune driers were being remodeled, and new types of tunnel driers were being constructed in Oregon to operate with forced draft and utilize the advantages of recirculation. Forced draft reduced the drying time of prunes as much as 50 per cent over natural draft driers. The utilization of forced draft in walnut driers reduced the time of drying approximately 50 per cent and permitted 100 per cent deeper loading of bin-type driers.

Presented before the Rural Electric Division at the annual meeting of the American Society of Agricultural Engineers, at Estes Park, Colo., June 1936.

Author: Agricultural engineer, Oregon Agricultural College. Assoc. Mem. ASAE.

With very few exceptions, the hop driers on the Pacific Coast, where 95 per cent of the American production of hops is grown, were natural draft driers as late as 1930. The Horst hop ranch in Oregon built a three-kiln, steam-heated, hop-drying plant, using forced draft with fans propelled by steam, in about 1905. A few years later a six-kiln, hop-dehydrating plant of similar type was built on the McLaughlin hop ranch. This was a very expensive type of plant to build, which was the chief reason that it was not generally adopted by the growers. The Horst ranch has never built any more of this type, even though it operates 20 to 25 other driers.

In 1930 a Mr. Seavy installed a 7-ft airplane propeller in the cupola of his natural draft drier, and operated the propeller with a $7\frac{1}{2}$-hp electric motor through a belt drive. Two other growers installed airplane propellers in the cupolas of their hop driers, to produce a suction and increase the draft through the kiln.

Because of the favorable reports of these few fans previous to 1933, many hop growers were interested in installing fans for the 1933 crops. During the summer of 1933 the Oregon Agricultural Experiment Station was called upon to supply information to hop growers, manufacturers, and salesmen, as well as to power company representatives, regarding the amount of power required to give best results with the new fan installations.

In order to meet this situation a survey was made by C. J. Hurd, agricultural engineer for the Mountain States Power Company, and myself, representing the Oregon station, which included a check on 56 different fans in 26 hop yards.

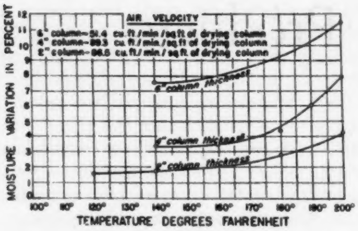
All the new installations were propeller-type fans mounted as suction fans in the cupolas of the kilns. There were a few airplane propellers and many 6 to 12-blade windmill type propeller fans. They were discharging from 20,000 to 40,000 cu ft per min against a static pressure of 0.18 in of water or less (average static, 0.10 in of water), and were operated by 2, 3, or 5-hp electric motors.

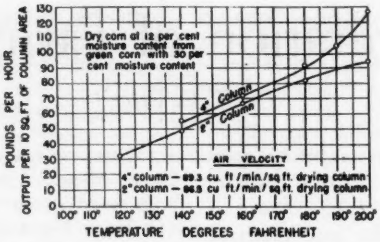
The average fuel consumption per 100 sacks of hops was 0.88 cords of wood with natural draft driers and 0.63 cords when cupola fans were used on the same type of drier. This amounted to a 29 per cent decrease in fuel consumption. The loading of the kilns was increased from 24 in of hops to 30 in, and the time of drying was decreased from an average of 24 to between 16 and 18 hours by the addition of fans. This increased the drier output 50 per cent and permitted drying at lower temperature, which is a factor in increasing the quality of the dried hops.

The growth of this power load is stated briefly and completely in the following report which I received recently from Mr. Hurd, of the Mountain States Power Company; this company serves about 50 per cent of the hop-growing area in Oregon:

"Previous to 1933, only one hop drier used electric-motor-driven fans on our lines. This was on the Titus farm near Independence, Oregon, where two 15-hp multivane fans were used in a Needham-type drier (oil furnace with hot air tubes under air pressure feeding into the drier room).

"During the 1933 season 239 hp (48 units) in fan load was added in the Independence hop area, with an added





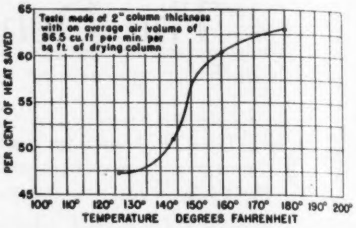


FIG. 1 (LEFT) VARIATION IN MOISTURE PERCENTAGE OF CORN FROM INSIDE AND OUTSIDE OF COLUMN. FIG. 2 (CENTER) EFFECT OF DRYING TEMPERATURE ON THE RATE OF OUTPUT OF DRY CORN. FIG. 3 (RIGHT) HEAT SAVED AT VARIOUS DRYING TEMPERATURES BY RECIRCULATION OF AIR

estimated revenue of $1,673. Although this load is of short duration, being from three weeks to a month, it has stimulated the interest of hop growers for other motor applications, such as electric-driven hop balers and irrigation.

"In 1934, 42 additional units were installed with 252 hp and $1,856 in added revenue.

"In 1935, 12 additional units were installed with 60 hp and $435 in revenue. By the fall of 1935 nearly every hop ranch had motor-driven fans and each farm was drying from 75 to 90 per cent of its hops by forced draft, although not every kiln was equipped.

"A summary of this increase shows 451 hp and $2,979 revenue from hop drying. Since no additional generation or distribution facilities were necessary, with the exception of about four miles of line changing from two-wire 11,000-volt, single-phase to three-phase, 11,000-volt, this load is a profitable one to the power company."

The Portland General Electric Company serves nearly all of the balance of the hop-growing area in the state, and the growth of the hop-drier fan load and revenue was similar in that territory to the one reported above. I would estimate the annual power revenue from hop-drying fans in Oregon at $5,000.

Mr. Hurd has also reported to me on the importance of the prune-drying load to his utility, which I quote as follows:

"Forced-draft prune driers have been used extensively in Oregon for over 10 years. The annual load on the system of The California, Oregon, and Mountain States (Power Co.) varies considerably with the prune crop and is from 1,000 to 1,500 hp, with revenues varying from $6200 to $11,000. Although the equipment is installed, many units are not used during seasons when the prune crop is light.

"The prune season, which is about one month to six weeks in length, usually follows the hop load, so there is good diversity in these two loads."

This represents somewhat more than half of the prune-producing area in Oregon. The Portland General Electric Company serves most of the balance of prune acreage in Oregon and has a prune-drier fan load of 500 to 1,000 hp and revenue estimated at $5,000. All of the dehydrators operate 24 hr per day during the drying season and therefore have a good daily load factor, even though it is a seasonal load.

There has been much research on dehydration of farm products. Prune drying has been studied more than the drying of any other commodity. The use of forced draft and experimentation with recirculation of part of the air through the prune drier has made it possible to control the relative humidity in the drier and greatly improve the quality of the dried product, to dry at a higher temperature, to reduce the time of drying, and to reduce the fuel requirement per ton of output. However, there are many questions being asked regarding changes in prune-drier construction for the purpose of increasing efficiency and reducing construction costs, for which answers must yet be worked out through experimentation. It was so easy to improve over the old natural-draft prune drier that many driers were built which accomplished this, but I am quite certain there is much room for further development. One of the leading questions in Oregon at the present time is, "Can a prune drier be designed or remodeled to efficiently use an air pressure of 0.10 to 0.20 in of water and thus be able to use a propeller fan, or are higher pressures necessary, requiring the higher-priced multivane fans?"

A small amount of research work has been devoted to improvements in hop drying in the United States. A project is under way in Oregon at the present time to study the conditions of drying which are required to maintain high quality. Also certain basic information for drier design is being obtained, such as rates of air flow through various kiln depths of hops, effect of recirculation, and rates of drying at various temperatures and air velocities. The effect of various drying conditions on quality is being determined by chemical analysis of samples, and by physical examination by experienced judges from the Hop Growers Association. There is quite a difference in opinion among growers as to the temperature at which hops should be dried, and the experimental drying is followed with considerable interest.

AIR VELOCITY AT VARIOUS STATIC PRESSURES THROUGH A 30-INCH KILN OF GREEN HOPS

Static pressure, in inches of water	Velocity of air above hops, ft per min
0.10	24
0.15	30
0.20	36
0.25	41
0.30	46
0.35	50
0.40	53
0.45	58

Research workers have been devoting a great deal of time and study to the problem of artificial hay drying. The cost of hay drying must be sufficiently low to be attractive to producers and buyers when all factors are considered. If or when artificial hay drying becomes a general practice, many thousands of horsepower will be required to operate the equipment.

Harold T. Barr reports[1] that a hay drier having a capacity of 1 to 1.25 tons of hay per hour requires 30 hp in electric motors to operate the cutter, drier fans, conveyors, and oil-burner pump. He also estimates that the power consumption per ton of dry hay will do 22 kwh. This power would probably cost 25 to 50 cents per ton of dry hay. This would require a large block of electric power, if artificial hay drying should become a general practice.

[1]Louisiana Bulletin 261, "Artificial Curing of Forage Crops."

It appears that Oregon might well devote some time to consideration of corn drying. The annual importation of corn into Oregon amounts to approximately 1,000 carloads, or 40,000 tons. A conservative price for this corn would be $30 per ton, which would amount to $1,200,000.

Agronomists and farmers have demonstrated that we have an adequate supply of land that can produce 40 bushels or more of corn per acre in western Oregon, but the moisture content at time of harvest will be from 25 to 35 per cent, and because of the mild winter weather, storage of such corn in cribs may result in considerable loss. The cost of shipping corn into Oregon from the Middle West is $7 to $10 per ton. If our farmers can produce yields comparable to the Middle West, they can utilize the freight differential for artificial drying costs, and still leave the producer with as much in return for growing the crop as the Middle West farmer would receive.

For the above reasons, we have been conducting experiments on corn drying at the Oregon Agricultural Experiment Station for the past few years. The Oregon corn-drying problem is largely one of drying on the farm, since we have no equipment of this kind available at our warehouses and elevators. A few growers are raising and drying from 40 to 100 acres of corn each, and are finding it a worthwhile crop to include in their crop rotation program.

Forty tons of dry shelled corn were turned out from a bin-type walnut drier, which with minor changes was converted to an ear corn drier. Cost of drying this corn was between $3 and $4 per ton. This entire crop was sold to one poultryman within three miles of where the corn was produced.

We have been endeavoring to develop a shelled corn drier at the experiment station, and have built an experimental drier. The corn is dried in two vertical columns which are formed by 1/4-in-mesh screen, which may be held from 2 to 6 in apart. This determines the thickness of the column. The space between the two columns is boxed in. Heated air is blown into this enclosure and passes through the two columns of corn to exhaust chambers. Part of this air is recirculated through the heating plant. The recirculation affects a considerable saving in fuel. The corn is removed from the bottom of each column by a corrugated roller which serves as a mechanical draw-off. These rollers are operated by an adjustable speed mechanism so that the output can be regulated to any desired per cent of moisture. It then operates as a continuous process drier. This is a very simple drier and is easily adapted to farm operating conditions.

A large number of performance tests have been made. Corn has been dried at various temperatures from 120 to 200 deg F, and column thickness has been tested at 2, 4, and 6 in. Various air velocities through the column have been tested to determine the effect on drying. Fig. 1 shows the disadvantage of a 6-in column. This objection is due to the large differential in moisture percentage between corn from the inside of the column and the corn on the outside of the column. This is largely corrected in the 4-in column, particularly at temperatures of 160 and 170 deg, where moisture differential across the column does not exceed 4 per cent. The 2-in column was not entirely satisfactory because the corn did not flow down through it freely at all times.

Fig. 2 indicates the rate of drying per ten square feet of drier column for both the 2 and 4-in columns at various temperatures. It is apparent from this curve that, if the corn is dried at a temperature between 160 and 180-deg, the output is much larger than at lower temperatures.

Fig. 3 shows the per cent of heat saved by utilization of recirculation of air from the drier at various temperatures.

The fuel required to reduce green corn at 30 per cent moisture to one ton of dry corn at 12 per cent moisture is approximately as follows: 15 gallons of fuel oil; 0.14 unit of sawdust, 0.10 cord of fir wood; or 0.09 ton of coal. The oil cost would be about 75 cents and the wood or sawdust 45 cents per ton of dry corn.

In conclusion, I wish to call attention to the very large blocks of power which are being used in the operation of farm dehydrators. As research continues in the problems of dehydration of farm products, we will undoubtedly find increased uses for electric power in this field.

Natural Drying of Forage Crops

(Continued from page 434)

curing plants. Two of these factors, low relative humidity and high temperature, have proved harmful, or at least of no value under average summer weather conditions, with alfalfa in Mississippi. The relative humidity was found higher and the temperature lower in the double windrow than for readings at the same time in the swath, and the rate of moisture loss was greater in the windrow. It is hoped that we may yet be able to more accurately measure the intensity of these factors and correlate their effect upon all qualities of the finished product.

To eliminate the handicap offered by the impervious stem wall of the larger hay plants a combination mower and crusher has been built by the Agricultural Engineering Department of the Mississippi Experiment Station and from results of previous crushing tests at this station, we should be able to cure Johnson grass and soybeans within one day's time. This machine is propelled and driven by the tractor and should be built and sold by machinery companies for a cost not exceeding $250.00. If future results are as favorable as those of past tests, this machine will be of considerable value to the southern farmer since the chief hay crops of this region are made up of the large-stemmed plants which respond most favorably to crushing. The Cushman mower-crusher developed in California has been in operation for about four years with very favorable results, with alfalfa.

With the advent of the new soil conservation program we, as agricultural engineers, have an enormous task to perform in helping with the control of erosion losses, and this is indeed a worthy task. However, the checking of erosion at present will not be a lasting solution of the problem, for there will be the natural recurrence of the same conditions unless a very extensive and intensive educational program is carried to completion. Therefore, if we can help the small or average farmer to cure his soil conserving crops surely and economically, another trust will be ably kept and men within the realm of engineering will have greater claim to their existence as a benefit to the agricultural industry.

NEWS

Technical Division Program Plans Announced

PROGRAMS for the winter technical division meetings of the American Society of Agricultural Engineers to be held at the Hotel Stevens, Chicago, November 30 to December 4, inclusive, are taking shape rapidly under the direction of the division chairman.

The meetings, as usual, are scheduled for the week of "The International," during which round-trip tickets to Chicago by rail are available at reduced rates from all parts of the United States and Canada.

A joint session of the Power and Machinery, Farm Structures, and Rural Electric Divisions, for a symposium on "Chopped Hay and Hay Silage Processing and Storage" is in process of development. It is planned to feature research and development of equipment and methods for processing, storage, and prevention of spontaneous combustion. This session is marked for Wednesday afternoon, December 2. No detailed announcement of other program plans of the Rural Electric Division has as yet been received.

POWER AND MACHINERY DIVISION

As an especially live and technically controversial subject with which to open its meeting on Monday afternoon, November 30, O. E. Eggen, chairman of the Power and Machinery Division, has chosen "Fuels for Farm Tractors: Engineering and Economic Aspects." It is planned that this symposium will begin with a presentation of the user's viewpoint by a college agricultural engineer. It is to be followed by engineers from the industries presenting and discussing "Fuels for High-Compression Gasoline Engines," "Fuels for Kerosene-Distillate Engines," "Fuels for Electric and Compression Ignition Oil Engines," "Tractor Fuels from the Refiner's Viewpoint," and "Need for Standardization of Tractor Fuels."

On the following forenoon (December 1) "Mechanical and Economic Requirements for a One-Plow Tractor" are to be the center of attention in a symposium designed to bring out "The Tractor Engineer's Viewpoint," "The Implement Engineer's Viewpoint," and "The Broad Agricultural Engineering Viewpoint." Engineers from the industries are slated to present and discuss the first two viewpoints. Leading power farmers and agricultural engineers in public service are to cover the latter viewpoint in a series of brief discussions.

A feature of the afternoon session on Tuesday, December 1, is to be an address by a representative of the Farm Equipment Institute on "Today's Challenge to the Engineers." R. U. Blasingame, president of the American Society of Agricultural Engineers, is scheduled to deliver a response to the challenge. Other subjects assigned to this session include a talk on "Farm Machinery Trends in Europe," and a paper on "Testing Equipment and Procedure for Tillage Tools."

Papers on "Results of Field Studies of the Small Combine," "Rootbed Preparation vs. Seedbed Preparation," "Removal of Spray Residue from Farm Products," and "Vapor Spraying for Insect Control" have been tentatively scheduled for the session on Wednesday forenoon, December 2.

FARM STRUCTURES DIVISION

Round-table discussions and symposiums will be featured in handling subject matter for consideration of the Farm Structures Division.

"Farm Storage of Grain" is scheduled for its opening session Monday afternoon, November 30. Major contributions will be progress reports of the federal cooperative research project.

A session Monday evening is to be devoted to "Cooperative Building Plan Services," with both active and proposed services up for discussion.

"Farm Building Insulation and Ventilation" will occupy the Division on Tuesday morning, December 1. Attention will be directed toward new developments in requirements, equipment, and materials.

Structural design and interior arrangement will be featured in the "Small Farm House Design" symposium slated for Tuesday afternoon. A brief report and discussion on "Insurance Rates in Relation to Building Construction" is also to be heard the same afternoon. Committee and informal group round tables are in line for Tuesday evening.

Wednesday morning's program for the Division has not yet been announced.

SOIL AND WATER CONSERVATION DIVISION

Technical papers fill the program planned for the Soil and Water Conservation Division of which C. E. Ramser is chairman. Thursday and Friday, December 3 and 4, are the days set for its meeting.

U. S. Soil Conservation Service engineers are to contribute to the opening session papers on "The Water Conservation Engineering Program of the Soil Conservation Service in the Northern Great Plains States," "Wind Erosion and Its Control in the Great Plains Region," and "Hydrologic Measuring Equipment and Its Installation on the Watershed and Hydrologic Project at Coshocton, Ohio."

These are to be followed in the afternoon by Bureau of Agricultural Engineering and university agricultural engineers with papers on "Farm Operating Efficiency," "Agricultural Engineering in the Shelter Belt," "Supplemental Irrigation in the Humid Region," and "Research Work Carried on in Connection with CCC Drainage Camps."

It is planned to have an hydraulic engineer open the Friday morning session with a paper on "Results of Experiments on the Flow of Water through Drop Inlet Culverts and Other Erosion Control Structures." It is to be followed by "Recommendations for Terrace Design Based on the Results of Experiments at the Statesville Erosion Experiment Station," and by a report of "Use of Drop Inlet Soil Saving Dams in the Wisconsin Soil Conservation Program."

"Methods and Cost of Terrace Construction, with a Discussion of Influencing Factors," "Terrace Cross Sections as Influenced by Soil, Crops, Land Slopes, and Farm Machinery," and "Relative Cost and Effectiveness of Different Methods of Terrace Outlet Control" are the subjects listed to be contributed to the closing session, Friday afternoon, by Soil Conservation Service representatives.

North Atlantic Section Meeting at Skytop

THE completed program for the three-day meeting at Skytop Lodge, Skytop, Pennsylvania, October 15, 16, and 17, of the North Atlantic Section of the American Society of Agricultural Engineers, includes several changes and amplifications of the tentative program announced in AGRICULTURAL ENGINEERING for September.

In addition to George A. Rietz, chairman of the Section, and R. U. Blasingame, president of the ASAE, two others appear in the opening session schedule. They are Andrew S. Wing, with a paper on "Farm Architecture," and John M. Carmody, who will explain "The Federal Rural Electrification Program."

A symposium on engines of today and tomorrow, emphasizing the newer features and expectation of trends in internal-combustion engines for farm use, has been arranged for the evening round table on power and machinery.

The rural electrification round table will include presentations on "The Electric Fence," by H. W. Riley; "Air-Conditioned Poultry Brooder Houses," by J. E. Nicholas; "Freezing Fruits and Vegetables," by H. Sterling; and "Adequate Farm Wiring," for which no leader has been designated.

In the farm structures round table S. P. Lyle, vice-president of the American Society of Agricultural Engineers, will lead a symposium on "The Northeastern Farm Building Plan Service."

Informal discussions of drainage, irrigation, and soil conservation work in the North Atlantic states will occupy the soil and water conservation round table.

Austin L. Patrick will represent the U. S. Soil Conservation Service on the morning session program for October 16. The title of his paper is "Erosion Control Problems in the Northeast Region."

In the Friday afternoon sessions the farm machinery group is to hold a symposium on economic and farm management aspects of modern power equipment for farming.

The other groups have papers scheduled. Rural electrification men are to hear papers as follows: "Developing Rural Uses for Electricity," by Geo. W. Kable; "New Developments in Electric Heat and Light for Plant Growth," by J. M. Arthur; "Load Building on Rural Lines," by D. E. Stultz; and "Rural Home Lighting Problems," by Miss Florence Wright.

In farm structures the subjects will be "Experiments with Poultry Housing," by F. L. Fairbanks; "Insulation and Ventilation of Potato Storage," by A. D. Edgar; and "Farm House Design," by a speaker not yet named. *(Continued on page 440)*

Rural Electrification at World Power Conference

GEORGE A. RIETZ, chairman, Rural Electric Division, American Society of Agricultural Engineers, and one of the official representatives of ASAE at the Third World Power Conference, told that body in discussion Friday morning, September 11, of the Society's activities in rural electrification.

The text of Mr. Rietz' remarks before the Conference, in which he credits agricultural engineers with leading the technical progress of rural electrification, follows:

"I appreciate the opportunity to briefly discuss the subject of rural electrification as viewed by the hundreds of agricultural engineers in this country. This group is interested in the sound development of any movement which promises to improve business and living conditions on American farms.

"Members of the American Society of Agricultural Engineers are to be found in many different organizations, including agricultural colleges and experimental stations, the U. S. Department of Agriculture, utility companies, electrical equipment manufacturers, farm machinery manufacturers, county agent organizations, committees, and farmers themselves. Their work may be in research, engineering education, or sales.

"Our members became active in rural electrification twelve or thirteen years ago, and the work of our Rural Electric Division has continued to be an important branch of our Society activities. Our primary concern is to do our part in making electric service most practical for, and profitable to, the farm family. We are interested in having the benefits of electric service available to the largest possible number of farm families; however, we realize that a very important factor in determining how many farms will be served, is how much that service means to the farmer and to the group operating the electric system.

"Each farm is a combination of an industrial or commercial customer, and a residential customer. Farm operations have been studied to determine the possible number of operations that could be performed electrically to the advantage of the farm operator. Hundreds of electrical test and demonstration farms were established throughout the country. The number of possible uses for service outside the residence proper varies with the type of farm served. The results of this undertaking are indicated by the fact that as early as 1930, a list had been compiled of some 200 uses for electricity on all types of American farms. There has been a continuous effort to expand this list through research programs of private and public groups, that will result in making the service more valuable to the farm user and facilitate the extension of service lines beyond present accepted limitations.

"Our endeavor has been, primarily, to find applications which increase farm profits, either through lowering the cost of production, improving the quality of the product, or increasing the quantity of production. These profits enable the farm family to enjoy many of the luxuries and conveniences of service in the home.

"The most difficult job has been to get farm customers to adopt electrical farm equipment for every operation to which it has been profitably applied. We realized that they would not purchase equipment with which they were not thoroughly familiar. A large group of men especially trained in the practical use of electrical equipment on the farm have rendered valuable assistance to farm customers by means of personal contact, radio programs, informative bulletins and articles, motion pictures, advertising, group meetings, etc. This effective educational and sales job must be continued to convince farmers that they will profit through a greater use of electricity.

"If they are to depend upon electrical equipment in their farm operations, that equipment must be of the highest quality and they must have assurance of a continuous supply of power. They do not purchase all equipment at one time, and the extent to which they expand their uses for electricity is dependent, in a large measure, upon the satisfaction from its previous uses.

"Farms in many sections are widely separated, a high percentage of them are operated by tenants, and a large number are devoted to types of agricultural production that do not afford many opportunities to employ electricity profitably. These conditions retard progress in the extension of lines, which is reflected in the percentage of farms served. The accomplishment to date—electric power line service to over three-quarters of a million farms which purchased nearly 1,700,000,000 kw-hr last year, certainly deserves recognition. It is natural that lines have been built in areas of greatest concentration and to connect the types of farms which can make the greatest use of the service.

"We must continue to support the extension of electric service into rural areas with sound programs of research, development, education, and sales. The agricultural engineers scattered throughout organizations at work on this problem are optimistic regarding its future and will continue their wholehearted support of the program."

Pacific Coast Section Program Announced

A TWO-DAY meeting of the Pacific Coast Section of the American Society of Agricultural Engineers has been scheduled for October 30, at the University of Idaho, at Moscow, and for October 31, at the State College of Washington, Pullman, Washington, eight miles west of the Idaho institution.

For the day at Moscow a paper on "Electric Fences," by J. B. Rodgers, has been scheduled, with a prepared discussion by H. N. Colby.

Oscar W. Sjogren is to give the dinner address, and the president of the Idaho Student Branch of the ASAE is slated for a luncheon address.

In addition, L. T. Jessup and F. E. Price are scheduled for papers on unannounced subjects. A representative of the University of California is also to have a place on this session, but neither the engineer nor his subject have as yet been named.

At Pullman on the following day, J. C. Marr will report on "Snow Surveys."

A session on some phase of soil conservation is to be built around a paper by T. R. Horning and prepared discussions by Neal G. Preston and W. F. Hereth.

Following the meetings, opportunity will be afforded for inspection trips of the campuses of the meeting hosts, nearby soil conservation projects, and Grand Coulee Dam.

Agricultural Engineers Participate in Upstream Engineering Conference

THE meeting of the Upstream Engineering Conference was held in Washington in the U. S. Department of Commerce auditorium on September 22 and 23, and a young men's conference "On Behalf of a Continent" was held on September 24. Quite a number of agricultural engineers including R. U. Blasingame, president of the ASAE, L. F. Livingston, C. E. Seitz, L. A. Jones, A. T. Holman, G. E. Martin, P. C. McGrew, R. A. Norton, J. S. Glass, M. L. Nichols, G. E. Ryerson, L. C. Tschudy, C. A. Frye, C. E. Ramser, S. P. Lyle, S. H. McCrory, W. D. Ellison, W. H. McPheters, C. L. Hamilton, J. T. McAlister, C. V. Phagan, and D. W. Teare, attended the Conference.

George D. Clyde, dean of engineering, Utah State Agricultural College, presented a paper on the "Control and Use of Small Streams." In his paper he referred to the use of check dams and spreading methods for the reduction of velocities in mountain streams, devoting his talk principally to western conditions. He described difficulties encountered from mud flow and the large amount of debris in mountain streams, and stressed the importance of sound engineering practice and design in the construction of flood control and erosion control structures. In E. R. Jones' discussion of this paper, read by Noble Clark, assistant director of the Wisconsin Agricultural Experiment Station, he concurred with Mr. Clyde's ideas relating to the importance of sound engineering design. He discussed principles of design and construction of dams, head spillways, and drop-inlet culverts, and emphasized the economy of building good, substantial structures. He discussed the control of erosion in gullies by means of check dams and vegetative methods with special reference to Wisconsin conditions.

Dr. H. H. Bennett presented a paper at this meeting on "Management and Use of Agricultural Lands, Including Farm Woods and Pastures." This paper was discussed by S. H. McCrory. Mr. McCrory discussed past experimental work in erosion control, such as was conducted at Raleigh, N. C., and gave considerable attention to all methods of erosion control, with particular reference to terracing. He recommended the use of farm ponds and reservoirs in regions of low rainfall, pointed out the need for legal machinery in planning successful and satisfactory projects in erosion control work, and stressed the need for additional research in soil and water conservation.

President Blasingame of the ASAE presented a paper on the "Comprehensive Engineering Point of View." In this paper he stated that the solution of upstream engineering problems requires the cooperation of all agencies such as (1) The sciences of engineering, biology, chemistry, physics, agricultural and economic sociology; (2) all government agencies, federal, state and local; and (3) all intelligent, *(Continued on page 452 — more News on page 448)*

What Agricultural Engineers Are Doing

REPORTED FROM USDA BUREAU OF AGRICULTURAL ENGINEERING

EXPERIMENTS with use of saline water in irrigation of citrus have begun near San Dimas, California, under the direction of Colin A. Taylor.

* * *

The central district reports the following work accomplishments by its CCC camps during July: 5,956,632 square yards clearing, 45,893 linear feet of tile reconditioning, and 1,824,320 cubic yards of excavation.

* * *

To facilitate the present program of maintenance and rehabilitation of the drainage systems in the work area of the drainage camps, the following additional heavy equipment has been received during the past month: 24 half-yard Diesel-powered draglines, 7 No. 40 tractors with power hoist attachments, 18 No. 22 tractors with backfiller hoist attachments, 45 two-yard capacity dump trucks, and 40 pickup trucks.

* * *

The ECW has allotted $40,000 to the Bureau of Agricultural Engineering for conducting drainage research in connection with the CCC drainage camp program. Plans are being developed for measurements to determine the value of Kutter's *n* in drainage ditches before and after maintenance work has been done, and to make measurements of runoff. Part of the funds will be expended in an attempt to develop better ditch-maintenance equipment.

* * *

Active work on the wheat storage experiments at Hays, Kansas; Urbana, Illinois; and College Park, Maryland, is nearly completed for the season. Ventilated bins at Hays and Urbana carried the grain through with much less heating and damage than the unventilated bins. However, the results this year may be more favorable to ventilated bins than in normal seasons on account of the very dry weather. Wheat in ventilated bins at College Park remained in good condition much longer than similar wheat in unventilated bins, but has finally reached temperatures at which damage will occur if not moved and cooled. All wheat in these experiments contained more than the normal amount of moisture. Great difficulty has been experienced in obtaining suitable wheat for the experiments in North Dakota, because the drought conditions resulted in the wheat being very dry at harvest time.

* * *

J. R. McCalmont is setting up equipment for measurement of pressures in one of the concrete silos at the Beltsville (Maryland) research center. The panel and calibrated steel bar method used in measuring pressures in corn-cribs will be used in the work.

* * *

J. W. Simons reports that the experimental house at Athens, Georgia, is practically completed, and that test work will soon be started. This is a three-room farmhouse so built that ceiling heights can be changed from 8 to 11 ft and that doors and windows can be shifted to any part of the wall. Various types of construction may be substituted in the walls. The effects upon comfort of ceiling height, position of openings, and construction, are to be tested.

* * *

A plow-test unit designed by I. F. Reed has been completed at the USDA farm tillage machinery laboratory, Auburn, Alabama, and worked satisfactorily in preliminary tests. This unit measures the horizontal and vertical forces on a plow, both at the hitch point and at the rear. Data obtained with this device, using different settings of the hitch, will enable calculation of the magnitude, direction, and location of the forces required to hold a plow bottom in its working position. Preliminary tests are now under way at the laboratory on a universal test unit planned to be used in a study of the effects of soil type and condition, and size, shape, and setting of disk on reactions set up in and by the disk. The shop facilities at the farm tillage machinery laboratory have been increased by the installation of a 200-ampere arc welder, a 28-inch upright drill press, and a 3-hp pedestal-type grinder.

* * *

Fertilizer placement experiments in Pennsylvania were recently inspected by G. A. Cumings. Tobacco at Lancaster, Pennsylvania, responds very little to potash in the fertilizer mixture applied broadcast in local practice, but our experiments indicate increased plant growth when the material is confined to a short band at each side of the plant. A rather extensive fertilizer-placement demonstration program is in progress by the New Jersey agricultural extension service. The demonstrations have shown convincingly that side placement of fertilizer insures more uniform germination, and higher yields of lima beans, peas, and sweet corn compared to local practices. Recently improved machines for this purpose have been adopted by a number of New Jersey farmers.

* * *

W. R. Humphries and George Stafford have returned from the corn belt where data were obtained on performance of many combines harvesting small grain. Recent improvements have made small power-take-off machines applicable to a wide variety of crops in the corn belt. On pneumatic tires these machines can be pulled at higher speeds than the large machines, and two-plow tractors seem to have ample power for operating them at 5 miles per hour.

* * *

During the past month a bibliography on flow of water around bends was issued.

Contributions Invited

All public-service agencies (federal and state), dealing with agricultural engineering research and extension, are invited to contribute information on new developments in the field for publication under the above heading. It is desired that this feature shall give, from month to month, a concise yet complete picture of what agricultural engineers in the various public institutions are doing to advance this branch of applied science.—EDITOR.

Reported from University of Missouri

A POULTRY housing project, under J. C. Wooley, is giving special attention to the adaptability of the double-deck house for Missouri conditions.

* * *

Another project under Mr. Wooley is on improvement of terracing machines, working with the Missouri machine and with the Texas and Corsicana blade machines. Running boards devised for each of these machines take the place of seats and enable the operator to control the depth by increased use of levers and by shifting the location of his weight.

* * *

M. M. Jones' research interest is on the subject of tillage. Also he is making a study of the practicability of the electric fence and has made some improvements simplifying the apparatus. He is also working on a project on silo capacities and silage densities.

* * *

Kenneth Huff has charge of structures work in extension and has been working cooperatively with the poultry extension specialists on a project having to do with the improvement of eggs in Missouri.

North Atlantic Section Program

(Continued from page 438)

Soil and water conservation interest for the afternoon will center on papers on "Engineering Aspects of Farm Operating Efficiency," by G. R. Boyd; "Recent Developments in Drainage Research," by J. R. Haswell; "Drainage Maintenance Work of CCC Camps in Maryland and Delaware," by R. W. Carpenter, and "Supplemental Irrigation in the Eastern States," by F. E. Staebner.

No further announcement of plans for the dinner on Friday evening, October 16, has been made.

Saturday morning, October 17, rural electrification and farm structures men will hear jointly a paper on "Protection Against Lightning," by W. L. Lloyd, Jr.

When they split for the separate parts of their programs, the electrification specialists will hear "New CREA Developments," by Dr. E. A. White; "Four-H Electric Clubs," by G. A. Sawin; "Looking in on Rural Electrification," by L. S. Caple; and "The High Speed Buhr Mill," by a speaker still to be selected.

Farm structures subjects will be "Farm Fire Prevention," by H. E. Roethe, and "Construction and Refrigeration of Farm Apple Storage," by C. I. Gunness.

Before the closing soil and water conservation session C. E. Ramser will report on "Watershed and Hydrologic Research Studies," C. A. Frye will speak on "Engineering Problems in Soil Erosion Control," and C. L. Hamilton will present the subject of "Controlling Erosion in Terrace Outlet Channels."

A symposium on the small grain combine in eastern agriculture will occupy the farm machinery men during their closing session.

Only **TOUGH MATERIALS**

can trail along with a tractor

● Parts used in modern agricultural machinery must be designed to travel in fast company . . . must be made of materials that offer improved resistance to the increased stresses, shocks and abrasion that accompany tractor power operation. By using parts made of Nickel Alloy Steels and Nickel Cast Iron, farm machinery of every type can be made more dependable and enduring. The superior hardness, toughness and strength of the Nickel Alloys reduce the cost of upkeep by slowing up depreciation.

● The more numerous the moving parts, the greater the hazard of costly hold-ups. But when gears, connecting rods, bolts, forks, teeth, chain drives, crankshafts and other parts are made of tough Nickel Steels the danger of breakage and wear is considerably reduced. Hard, wear resisting Nickel Cast Irons are equally desirable for cylinder blocks, liners, engine heads, etc. Our engineers will be glad to consult with you and to recommend suitable applications and compositions.

ALLOY STEELS
NICKEL
CAST IRONS

THE INTERNATIONAL NICKEL COMPANY, INC.
67 WALL STREET, NEW YORK, N. Y.

Washington News Letter

from AMERICAN ENGINEERING COUNCIL

A GRAPHIC presentation of the engineering organizations of the United States and their "instrumentalities," sponsored by American Engineering Council, formed a part of the exhibit of the Third World Power Conference. The penetration of the engineer into the arts and industries, and the specialization that has taken place in the relation of the engineer to management of industrial and business enterprises of all kinds, is strikingly illustrated by the wide variety of national engineering organizations and by the objectives of the functional organizations which are supported by the so-called founder engineering societies.

This exhibit of the aims and objectives of the engineering organizations of the United States was prepared by the American Engineering Council in cooperation with the national, state, and local engineering societies, at the request of the officers of the Third World Power Conference. The exhibit was presented by American Engineering Council's committee on publicity for the engineering profession, as a contribution to furthering a public understanding of the work and purposes of the engineer. The exhibit and a special brochure prepared for distribution to the delegates of the Third World Power Conference, were both presented by the committee as a contribution to this wider understanding. Both the exhibit and the brochure bring together for the first time into a composite whole a complete picture of the engineering organizations of the United States.

The exhibit itself is unique and interesting. The central feature is a huge map of the United States measuring approximately twelve by fifteen feet. On this map are spotted the locations of the national engineering societies and their local sections, the state engineering societies and the independent local engineering groups. Grouped around the central feature are panels on which are presented the names and salient features of (1) the four national founder societies, (2) the instrumentalities or functional organizations, which are supported by the founder societies and by other national engineering bodies, (3) the list of fifty-three national engineering societies, (4) panels showing the names and locations of the state engineering associations and the local engineering organizations.

Brief descriptions of the objects and purposes of each of the functional organizations are presented on their respective panels. These functional organizations are as follows: United Engineering Trustees, Inc., The Engineering Foundation, National Research Council, American Standards Association, Engineers' Council for Professional Development, American Engineering Council, Engineering Societies Employment Service, and Engineering Societies' Library. The color scheme of the exhibit is blue, white, and gold, and the charts and panels have been prepared in such way that they can be readily disassembled and erected at future exhibits.

The brochure prepared by the American Engineering Council, in addition to containing descriptions of each of the functional organizations, lists the name, the secretary and membership, and principal activities of fifty-three national engineering societies, forty state associations and ninety-six local organizations. It contains also a brief article, entitled "Why the Engineer," contributed by Dr. William F. Durand, chairman of the Third World Power Conference and the John Fritz Medalist for 1935. Greetings from the engineers of the United States to the delegates to the Third World Power Conference are conveyed in the booklet, signed by the members of the American Engineering Council's committee on publicity for the engineering profession. They are Charles E. Stephens (chairman), Dr. Harrison E. Howe, L. F. Livingston, Watson Davis, Frank McCausland, and Charles K. Weston. The printing of the brochure was made possible through the courtesy of the Washington Society of Engineers.

GOVERNMENT AGENCIES' ACTIVITIES

Behind the scenes in Washington, there is emerging on the part of those in the employ of various old and new divisions of the government and on the part of those in charge of administrative responsibility, a clearer understanding of two fundamental truths. The first is that the wide flung government organization which has been set up under many of the New Deal agencies must be reassembled and consolidated. Not only is this desirable from the point of view of political expediency but it is rapidly becoming evident that only a complete reorganization will eliminate the waste and inefficiency which have grown up with scores of emergency proposals and organizations which have been undertaken.

The Students' Estes Park Meeting

By Hamilton Clark

A GRICULTURAL engineering students from the sixteen student branches of the American Society of Agricultural Engineers travelled from 300 to 2,000 miles to reach Estes Park, Colorado, in June to attend the Society's annual meeting. During the trip each representative was able to study the conditions of the country, and the type of people in other states.

Possibly the most beautiful drive of the trip was from Denver to Estes Park. Leaving Denver, the paved road made driving a pleasure, but as the destination became near, the road resolved itself into a winding trail upward. This road followed a madly rushing stream. The scenery in all directions was a panorama beautiful to behold. Trees and grass made a canopy, while the mountain peaks protruded with a most unusual color scheme. It was enough to give everyone the desire to forget all work.

But after having travelled these distances to the meeting, the student representatives had a desire to accomplish much in the time they were allotted.

The first meeting was called to order by President Doll, of the National Council of Student Branches. Ten of the sixteen branches were represented. They were Iowa, Ohio, Nebraska, Missouri, Kansas, Georgia, Minnesota, Oregon, Texas, and Illinois. During the first session L. F. Livingston, president of the American Society of Agricultural Engineers, welcomed the students, after which they heard four addresses. They were "The Agricultural Engineer in the Commercial Field," by L. J. Fletcher, Caterpillar Tractor Company; "The Agricultural Engineer in the Extension Field," by Mr. Livingston, E. I. du Pont de Nemours and Company; "The Agricultural Engineer in College Instruction," by M. M. Jones, University of Missouri, and "The Agricultural Engineer in Research," by F. W. Duffee, University of Wisconsin, read by E. L. Barger of Kansas.

Following these addresses, A. W. Turner, representing the FEI award committee, classified some of the misunderstandings concerning the FEI Cup and its award. The remainder of the morning was spent meeting others present at the meeting.

The sessions of the ASAE were arranged so as to leave the afternoons open, allowing everyone a chance to go on sightseeing tours. The party *(Continued on page 452)*

Officers of ASAE National Council of Student Branches at Estes Park meeting. Front row, left to right, Clayton Lyle (Texas), first vice-president; Howard Fujii (Oregon), second vice-president; Lawrence Ekromme (Iowa), president; Paul Doll (Missouri), past-president. Back row, Hamilton Clark (Georgia), secretary

YOUR EQUIPMENT *and* GOODYEAR

A COMBINATION THAT OFFERS YOU VERY DECIDED PROFIT ADVANTAGES!

Whether it's selling peanuts or perambulators, tractors or tractor tires—there's no denying the plus advantages of having prestige, preference and performance on your side.

Implement and tire dealers know. And they will tell you frankly why Goodyears sell easier—why the same holds true of farm implements that are Goodyear equipped.

Why? Because farmers want them. And they want them because they found the Goodyear All-Traction Tire more tire for their money—better on every type of job, in every kind of soil—better in every way.

With Goodyears on the equipment you manufacture—it will show up better—it will sell easier—it will make more enthusiastic users of your products. See if we aren't right.

THE GOODYEAR TIRE & RUBBER CO., INC., AKRON, OHIO

• • •

Listen to the Goodyear Broadcasts of the Literary Digest Poll for President (John B. Kennedy, commentator)—Monday, Wednesday, Friday Evenings NBC Blue Network.

GOODYEAR ALL-TRACTION TIRE

The greatest tractor tire ever built. It gives 50% more traction—traction forward, backward, on hillsides. It gives 30% more drawbar pull. It is easier cleaning. It has 48% more rubber—100% more shoulder tread.

NEW TIRE FOR ROLLING IMPLEMENTS

This new Goodyear Implement Tire was specially built for the rolling farm machines that tractors pull. Easy rolling. Prevents side slip. Saves further on fuel—multiplies other advantages of tractor pneumatics.

There's a GOODYEAR BATTERY now!

GOODYEAR ALL-TRACTION TRACTOR TIRE

AND THE SPECIAL ***IMPLEMENT TIRE*** FOR ROLLING FARM MACHINES

Upstream Engineering Conference

(Continued from page 439)

courageous, and conscientious leaders and farmers.

Mr. McPheters presented a paper at the young men's conference on "Water Conservation Problems and Methods of Attacking Them in the Southwest Plains Area." In this paper he discussed water conservation problems, work being done toward accomplishing water and soil conservation, farm ponds, and 4-H Club work.

After the close of the meeting on September 24, members of the ASAE Committee on Soil Erosion assembled at the request of Mr. Holman, chairman, to discuss plans, objectives, and procedure for the coming year. Mr. Holman outlined objectives for carrying on the work of the various subcommittees and members of this committee who were present engaged in an active discussion of the objectives and methods of carrying on the work during the year. This meeting was attended by Messrs. Holman, McPheters, Norton, Tschudy, Ellison, McGrew, Hamilton, Frye, Martin, Glass, Ryerson, McAlister, and Phagan.

A suggestion was made for adding another subcommittee on farm reservoirs, which matter will be taken up with the president of the society as soon as all of the personnel for this committee has been selected.

Students' Meeting

(Continued from page 448)

Monday afternoon went up into Rocky Mountain National Park.

The ride through the park carried the group over the highest paved highway in the world. The highest elevation on this ride is 12,183 feet. Wild life here was plentiful. The mountain streams were full of fish. Wild deer, which were almost tame, could be seen along the drive. Perhaps the most interesting thing in Rocky Mountain National Park was the study of the beaver and their work. Agricultural engineers devise plans to check water in its wasteful rush downward, but never have they conceived a plan that has been more successful than the beaver dam.

The second student session began at 8:30 o'clock Tuesday morning. W. N. Danner, chairman of the student branch committee, gave a practical talk on "What Your Profession Expects of You." Following Mr. Danner, a student representative from each branch gave a report on activities of his branch for the year. Every representative was able to get pointers to take back to his branch, which should prove beneficial in carrying on their activities next year.

After the reports were given we had a lively discussion on the new constitution for the National Council of Student Branches. It was finally adopted with a few minor changes. The following officers were then elected:

Lawrence Skromme, Iowa State College, president

Clayton Lyle, Texas A. & M. College, first vice-president

Howard Fujii, Oregon State College, second vice-president.

Hamilton Clark, University of Georgia, Secretary.

Following group discussions, the students divided for their afternoon trips.

One group visited an excavation project by Smithsonian Institute to see their methods of exploration. This project was to uncover some relics leading to a study of the Folsom man. Folsom men were supposed to be the first inhabitants of this country. After having seen this project the party went to Fort Collins and inspected the University of Colorado. The newest addition to the University is an elaborate hydraulic laboratory. The party then began its return trip to Estes Park.

Wednesday was the one full day left open for students. The morning was spent visiting the division meetings that were of the most interest to each representative. There was a short session held by the newly elected national council officers to make plans to be carried out through the next year. Wednesday afternoon was spent in a complete tour of Estes Park. Wednesday evening the annual dinner of the Society was held, and proved to be perhaps the most enjoyable time of the entire meeting. The FEI Cup Award to the Iowa Student Branch was one of the features of the program. After the dinner a dance provided an enjoyable evening.

Russian Books Available

VOLUMES I and II, Theory, of a series on "Theory, Construction, and Manufacture of Agricultural Machinery," (translated title) edited by the late Russian scientist, V. P. Goriachkin, and published by the Institute of Mechanization, Moscow, U.S.S.R., have been announced as complete. Dr. J. B. Davidson, professor of agricultural engineering, Iowa State College, is authority for the statement that the books, written in Russian, contain exhaustive mathematical treatment of the theory of machines, together with a discussion of methods and equipment for testing. The books are extensively illustrated, cloth bound, 6x9¾ inches, 534 and 536-page volumes, respectively, and are distributed by the Society for Cultural Relations with Foreign Countries, 56 Bolshaya Gruzinskaya ul., 17, Moscow, U.S.S.R.

ASAE Meetings Calendar

October 15 to 17, 1936—North Atlantic Section—Skytop Lodge, Skytop, Pa.

October 30 and 31, 1936 (tentative)—Pacific Coast Section, at Moscow, Ida., and Pullman, Wash.

November 30 and December 1 to 3—Power and Machinery Division, Rural Electric Division, Farm Structures Division, and Soil and Water Conservation Division (individual and joint programs)—Stevens Hotel, Chicago.

February 3 to 5, 1937—Southern Section (in conjunction with annual convention of the Association of Southern Agricultural Workers)—Nashville, Tenn.

June 21 to 24, 1937 (tentative dates)—Annual meeting of the Society—University of Illinois, Urbana-Champaign.

Personals of ASAE Members

Earl D. Anderson has been appointed agricultural engineer in charge of the Republic Steel Corporation's new agricultural extension bureau, with offices in Chicago. He was previously with the Farmers' Mutual Reinsurance Association of Iowa. His new work will involve research and extension, contacting agricultural engineers, the federal department of agriculture, agricultural colleges, county agents, and farm organizations, as well as the metallurgists and engineers of his company, with a view to contributing to the solution of problems in the proper and economical use of steel products on the farm.

C. B. Richey, formerly rate-setter at David Bradley Manufacturing Works, Bradley Illinois, is now with the agricultural engineering department of Purdue University as instructor in farm power and machinery, filling the vacancy created by the resignation of C. N. Hinkle to accept a position with the Standard Oil Company.

Applicants for Membership

The following is a list of applicants for membership in the American Society of Agricultural Engineers received since the publication of the September issue of AGRICULTURAL ENGINEERING. Members of the Society are urged to send information relative to applicants for consideration of the Council prior to election.

K. M. Bostwick, graduate assistant, agricultural engineering department, Rutgers University, New Brunswick, N. J. (Mail) 203 Redmond St.

Orville C. Bumpas, camp superintendent, Soil Conservation Service, U. S. Department of Agriculture. (Mail) Box 37, Dresden, Tenn.

John L. Burgan, special representative, Empire Gas & Electric Co., Geneva, N. Y. (Mail) 730 S. Main St.

James C. Carrigan, engineering aide, Soil Conservation Service, U. S. Department of Agriculture. (Mail) ECW Camp SCS-7, Weeping Water, Nebr.

Thos. B. Chambers, head, section of engineering, Soil Conservation Service, U. S. Department of Agriculture, Washington, D. C.

George H. Daugherty, account executive, Byrne Advertising Agency. (Mail) 56 6th Ave., LaGrange, Ill.

O. E. Gianni, assistant agricultural engineer, Soil Conservation Service, U. S. Department of Agriculture. (Mail) Box 1151, Gallup, N. Mex.

Lowell M. Graves, junior agricultural engineer, Soil Conservation Service, U. S. Department of Agriculture. (Mail) Box 253, Alcester, S. D.

Ingram T. Hermanson, Soil Conservation Service, U. S. Department of Agriculture. (Mail) SCS-2, Presho, S. D.

L. R. Marchant, manager, Illinois Farm Supply Company, 608 S. Dearborn St., Chicago, Ill.

Earle K. Rambo, graduate assistant, agricultural engineering department, A. & M. College of Texas, College Station, Tex.

Mary F. Taylor, Rural Electrification Administration, Washington, D. C.

Walter G. Whitehead, sales manager, The Letz Manufacturing Co., Crown Point, Ind. (Mail) 124 N. Grant St.

Charles D. Young, agricultural representative, Caterpillar Tractor Co. (Mail) 709 Mitchell St., Ithaca, N. Y.

* * * IN THE WAKE OF THE HIGH LINE

NEW HELP FOR THE FARMER . . . AND NEW QUESTIONS FOR AGRICULTURAL ENGINEERS TO ANSWER

In the wake of the high lines come new questions, new problems. The major question of a few years ago was, "How can I get electricity?" Now it is, "How can I use electricity to get most benefit at lowest cost?" And as before, farm power users will come to the agricultural engineers for advice.

Westinghouse, for 50 years a leader in the electrical field, is prepared to help you meet this change in pace. As it pioneered in rural line equipment that makes distribution and farm wiring more economical, safer, so has Westinghouse pioneered in development of wiring equipment, motors and appliances that use rural line current economically.

Now ready for your use is the booklet, "Wired Help." Typical farm wiring diagrams, wiring equipment, appliances and motor applications are illustrated. Another handy aid is the Cost-O-Graph, a pocket device that places at your finger tips the answers to "how much current will it take?" Write Westinghouse Rural Electrification Department today for these free helps or for information concerning any other phase of rural electrification.

J 99432

FOR FARM WIRING
Nofuze Load Centers
Wiring Devices

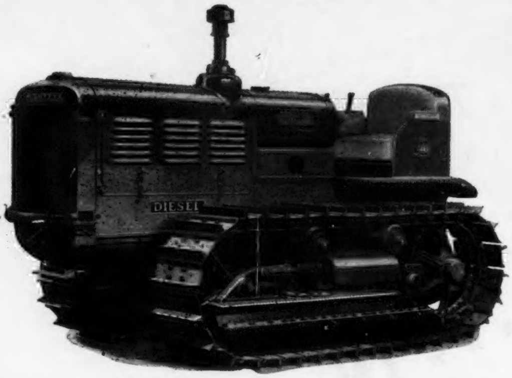
FOR HOME CONVENIENCE
Ranges
Refrigerators
Water Heaters
Washers
Ironers
Appliances

FOR FARM PROFIT
Motors and Control
Dairy Refrigerators
Yard Lights
Lighting Units

* * *

WESTINGHOUSE 1886 1936 GOLDEN JUBILEE

Westinghouse



McCORMICK-DEERING DIESEL TRACTRACTOR

The McCormick-Deering TD-40 is a powerful, compact, Diesel-powered crawler tractor offering exceptional economy and accessibility. It is particularly well suited for work in terracing and other soil-erosion-control work. Complete details will be supplied on request.

INTERNATIONAL HARVESTER COMPANY
(Incorporated)

606 So. Michigan Ave. Chicago, Illinois

Literature Received

HANDBOOK OF ENGINEERING FUNDAMENTALS, by O. W. Eshbach, E.E., M.S., editor-in-chief, and 40 contributors. John Wiley & Sons, Inc., New York, 1936. 1081 pages, illustrated; 6x9 inches; $5.00.

This is the first volume in the proposed new Wiley Engineering Handbook Series which represents a complete revision of the basic conception of American handbooks. Since mathematics, physics, and chemistry form the basis of all engineering, these are the fields dealt with in the new volume. "Eshbach" is designed to present in one compact volume a complete summary of the facts pertaining to the fundamental theory underlying engineering practice.

The first section presents a selection of mathematical and physical tables, including new and revised tables of the American Handbook series, in which particular attention has been given to arrangement, typography, and general convenience. In addition to well-arranged tables on engineering constants, properties of numbers, logarithms, trigonometric and hyperbolic functions, there is included a series of tables of conversion factors for weights and measures arranged in order of dimensional sequence, tables of integrals, standard structural shapes, and physical properties of metallic and nonmetallic materials.

Other sections offer such features as the presentation of dimension systems, systems of units, standards, and introduction to the theory of dimensional analysis; the systematically arranged and clearly illustrated fundamentals of theoretical mechanics and mechanics of materials with applications to beams, columns, shafts, and reinforced concrete; the modern theory of fluid mechanics as applied to the fields of hydraulics and aerodynamics; engineering thermodynamics, embodying the latest physical concepts of the fundamentals of heat engineering; the theory of the electric, magneto and dielectric circuits and their application to generalized networks and transient theory; the fundamental principles of general chemistry, chemical tables and industrial chemistry; the principles of light, acoustics and meteorological phenomena; an extensive handbook treatment of the properties of metallic and nonmetallic materials with reference to features of manufacture and use; and a discussion of the elementary legal aspects of contractual relations with which all engineers should be familiar.

An important feature is that of format. With readability in mind, the trimmed page has been fixed at 5½ by 8⅜ inches, permitting the use of a larger type size and larger illustrations and diagrams than was possible in the older type of handbook. The result is a much more beautiful page typographically.

This is a volume which every engineer, regardless of his specialty, will find a veritable treasure trove of information. The price is indeed a modest one for a book of over a thousand pages.

Correction Notice

ATTENTION has been called by the authors of the article entitled "Well Battery Design," appearing on page 293 of AGRICULTURAL ENGINEERING for July 1936, to an error as follows:

"The word '(grams)' appearing in the second line of the definition of the term *k'* on page 295, should have been omitted. The correct meaning of the symbol '*g*' appears in the last part of the paragraph."

EMPLOYMENT BULLETIN

The American Society of Agricultural Engineers conducts an employment service especially for the benefit of its members. Only Society members in good standing may insert notices under "Positions Wanted," or apply for positions under "Position Open." Both non-members and members seeking to fill positions, for which ASAE members are qualified, are privileged to insert notices under "Positions Open," and to be referred to members listed under "Positions Wanted." Any notice in this bulletin will be inserted once and will thereafter be discontinued, unless additional insertions are requested. There is no charge for notices published in this bulletin. Requests for insertions should be addressed to ASAE, St. Joseph, Michigan.

POSITIONS WANTED

CIVIL ENGINEER, with two years agricultural engineering experience in soil conservation work, including SCS camp layout, design of small earth dams, terraces and outlets; layout of diversion ditches; drafting, blueprinting, filing, time study, general estimating; camp engineer work, including layout of field work for camp crews, general supervision of field foremen, design of erosion control structures, and preparation of reports. Desires position in construction work or with machinery manufacturer in maintenance, demonstration, or research. Looking for permanent connection with opportunity for advancement. Location immaterial. Married. Age 27. PW-272

the BADGE of him who BELONGS

DESPITE the *presumption* it sets up, mere membership in the American Society of Agricultural Engineers is no *proof* of a man's high rank in technical talent. It does prove that he has met certain minimum requirements and has earned the esteem of colleagues who sponsored his application for membership.

But the Society emblem is *evidence* that native talent, be it great or small, is enriched by fraternity with the personalities whose minds fuse to form the pattern of progress in the methods and mechanics of agriculture. The wearer of the emblem waits not for the debut of an idea, but is present at its birth and helps to guide its growth.

Be you novice or veteran, your membership in the organized profession adds something to your efficiency, your vision, your influence as an individual engineer. The Society symbol on your lapel is token that you "belong." Wear it.